Fall 2014

Graduate students' motivation to teach plant sciences to K-12 audiences

Melissa Leiden Welsh
Purdue University

Graduate School Form 30
(Updated 11/20/2014)

PURDUE UNIVERSITY
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By Melissa Leiden Welsh

Entitled Graduate Students' Motivation to Teach Plant Sciences to K-12 Audiences

For the degree of Doctor of Philosophy

Is approved by the final examining committee:

Neil A. Knobloch

James P. Greenan

Kathryn S. Orvis

Helen Patrick

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Approved by: Roger L. Tormoehlen 12/05/2014

Head of the Department Graduate Program Date

GRADUATE STUDENTS' MOTIVATION TO TEACH PLANT SCIENCES

TO K-12 AUDIENCES

A Dissertation

Submitted to the Faculty

of

Purdue University

by

Melissa Leiden Welsh

In Partial Fulfillment of the

Requirements for the Degree

of

Doctor of Philosophy

December 2014

Purdue University

West Lafayette, Indiana

For my husband Jerrod - I salute the divinity in you.

ACKNOWLEDGEMENTS

The dream of a farmer's daughter and granddaughter of a teacher was realized in the pursuit to achieve this doctoral degree. I hold strong to the belief of learning as a lifelong process, to the measure of intelligence as it brings meaning and understanding beyond a single person and to the gratitude of a learner toward the village that continues to raise her to help others. Throughout this dissertation process my village grew from the small farming community in St. Lawrence, Pennsylvania to international colleagues across the globe. These pages are far too short to list all the names of those who have enlightened me along this journey but rest assured I hope our paths may cross again to thank-you in person.

A love of learning and an unquenchable desire to ask why or how started with my parents and siblings. To Gerald and Bernadette- Thank-you! for giving me life and the encouragement to reach for my goals. To Chris and Thad- Thank-you both! for the absolute shared passion for continuing our great-grandparents agricultural legacy and supporting my PhD dream. To Stephanie for loving me and missing me as only a special sister can as well as caring for Alex. To Janice and Briana, Thank-you for helping my brothers care for Jerrod and my farm while raising amazing, talented and beautiful children (Sophia, Gabrielle, Bryce, Jessica, Marisa and Henry). I am truly blessed to have such a hardworking and loving immediate family- you all inspire me.

Thank-you! to Jerrod's family as well as my aunts and uncles for your love and support via holidays, phone calls and messages online. Thank-you! to my lifelong friends Heather Kensinger and Nicole Farabaugh for unconditional love and support during late-night phone calls or online chats and quick weekend visits home. Thank-you for keeping me grounded during tense moments.

Thank-you to all my previous students! Keep reaching for your star and make it shine. Thank-you for encouraging me to find my star and grow as a teacher. And Thanks to all my past colleagues for your support and wealth of teaching advice over the years-teaching really is a team effort in public schools.

Thank-you to the YDAE family for a trio of years filled with amazing personal and professional experiences. I am a stronger person today through my encounters with each of you. Thank-you Dr. Tormoehlen for encouraging me with every endeavor I chose to explore as a novice social scientist and veteran teacher. Your enthusiasm for international educational and sheer love to help others grow as a professional in higher education are seeds of wisdom I look forward to sharing with my future colleagues. Thank-you! to Drs. Brady, Borron, Carroll, Esters, Pilat and Tucker for sharing your scholarly wisdom. Thank-you! to Dr. Talbert, Dr. Peters and Mr. Dan Gottschalk for sharing your view into the world of Agricultural Education. Thank-you! To those who nurtured my 4-H Spirit Thank-you!!! Dr. McKinley, Dr. McKee, Mr. Carroll, Mr. Fisher, Christy Blomeke and Purdue Collegiate 4-H. Thank-you all! for providing me an educational yet social escape from research and the support to advance to Extension education as a career choice. Thank-you to those who teach life lessons often overlooked in higher education. Thanks Jayne, Jane, Sharon, Linda, Craig Richard, Jack and Maria for supporting and encouraging in ways you likely didn’t know helped me to achieve this dream.

To my Purdue professors in the classroom and as mentors I am very grateful for your scholarly insights and shared love for learning. Dr. Obenchain, you opened my research eyes to a qualitative passion for my humanitarian heart. Thank-you Drs. Christ and Chatterjee for pushing me to figure out statistics and Dr. Smith for sharing your passion for research methods and natural resources social science.

This dissertation would not be what it is without the assistance of my awesome committee. I am very grateful for the guidance of my major advisor Dr. Neil Knobloch. I admire your ability to craft thought provoking research and the persistence toward scholarly perfection. Thank-you for introducing me to the academic words to describe the authentic actions of learners while facilitating my growth as an academic writer and not giving up. I appreciate these new skills and the opportunity to have worked with you on many of your projects at Purdue. Thank-you Dr. James Greenan for introducing me to the academic research side of Career and Technical Education. I really enjoyed your classes filled with stories of your teaching experiences and educational lobbying along with a keen eye for meticulous APA edits- greatly appreciated. Thank-you Dr. Helen Patrick for helping me connect the behaviors I observed as a K-12 teacher to theories in the educational literature. Your patience and scaffolding throughout your courses of instruction and as a committee member motived me to think deeper. Thank- you Dr. Kathryn Orvis for providing the nurturing moments I needed at just the right time along with sharing your love of plants and for the people who spend their lives studying them. I am grateful for your help in navigating the socialization process from a graduate student to a professor.

Thank-you to all the informal mentors I found along this journey at Purdue. I am a much more confident female scholar due to the exceptional wisdom shared with me by Dr. Rebecca Doerge and Dr. Linda Mason. Words can hardly express the gratitude I have for the pep talks, insight into academic life as a female scholar and the emphasis of balancing work and family. Thank-you Jamie and Kimber for causal chats that helped me find my way through days of academic fog.

To the past and current residents of the mouse maze- (YDAE graduate students), I extend a heartfelt thank-you. The stories and struggles we shared together were memories I will cherish. Thank-you! to Claire (Qi), Cecilia, Yakosa, Chimwemwe and Ben for providing a glimpse of your part of the world. Thank-you! to Annie, Lisa, Melissa, Matt, Liz, Krystin, Alee, Amanda, Alli, Elise and Jessica for sharing in life outside the office doors. Thank-you Christy Clary for a 4-H friendship at Purdue and as a 4-H colleague in the future- I hope we get to collaborate professionally someday. Bekah Northrup and Megan Anderson you are amazing women. The fun conference trips, the agonizing late nights at the office and the unconditional friendship with each of you remain a part of my favorite moments as a graduate student and Boilermaker in training. Megan, your support and kindness throughout the challenging moments of my Purdue studies has kindled an amazing friendship- the ice cream sharing kind of friendship.

My journey here would not have been possible without the encouragement from Helen Zitzelberger Eckley, Tom Kordish, Dr. Mia Barker, Dr. Sally McCombie, Dr. Edwin Fry, Zenda Kordish, Karen Bowman, Diane Malloy, Denise Horne, Msgr. Desmond McGee Jr., Msgr. Henry Krebs, Pranav Parekh, Joseph Galimidi and Ahmed Aldabbagh. I am most grateful to you friends for the wisdom you have passed along in casual conversations and am blessed by your influence in my life.

My love for growing and caring for plants started at a young age. I am very grateful to the agronomy, botany, forestry, and horticulture graduate students for sharing their passion for plant sciences with me throughout this study. I was inspired each time I encountered your passion for plants science literacy and in awe with the research that each of you do to continue to advance plant science to help solve challenges in the world. Thank-you Dr. Herb Ohm and all the co-principal investigators with the Partnership for Research & Education in Plant Breeding and Genetics at Purdue University, as this was an enriching educational experience for me. I am grateful for the research funding provided by this AFRI project along with the additional professional development funding provided to me by Dr. Knobloch.

There were times throughout this doctoral program that my best friend and husband reinvigorated my downtrodden spirit. Thank-you Jerrod for understanding me, helping me and loving me not only when I needed it most- but when I didn't realize I needed it. Hand in hand we have accomplished this dream and continued to grow closer. I am blessed to have you at my side Jerrod. And by the numerous wings in the heavens as felt by the wind on my cheek and by the warmth of sun on my face during troubled times have I been assured of GOD above with friends and family now passed as reminders of the blessings in my life.

"For, after all, everyone who wishes to gain true knowledge must climb the Hill Difficulty alone, and since there is no royal road to the summit, I must zigzag it in my own way. I slip back many times, I fall, I stand still, I run against the edge of hidden obstacles, I lose my temper and find it again and keep it better, I trudge on, I gain a little, I feel encouraged, I get more eager and climb higher and begin to see the widening horizon. Every struggle is a victory. One more effort and I reach the luminous cloud, the blue depths of the sky, the uplands of my desire."
― Helen Keller, *The Story of My Life*

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ABSTRACT

Welsh, Melissa Leiden. Ph.D., Purdue University, December 2014. Graduate Students' Motivation to Teach Plant Sciences to K-12 Audiences. Major Professor: Neil Knobloch.

Graduate students' motivation to share their knowledge and research with K-12 audiences as future scientists is informed by their beliefs and perceived value of science literacy outreach. Graduate training programs in academia integrate outreach teaching components to equip future scientists with a variety of communication skills, which may reflect either a transmission of knowledge to the learner or through engagement with the learner. As such, the education component of the "Partnership for Research and Education in Plant Breeding and Genetics" grant sought to train graduate plant science students (N = 17) to disseminate their research to K-12 audiences. Graduate students participated in outreach teacher training using Learner-Centered Teaching (LCT) strategies to develop and conduct two science lessons for K-12 audiences in a non-formal and formal educational settings. The purpose of this mixed methods study was to describe the outreach teaching beliefs and values of plant science graduate students after receiving the outreach training. The researcher used a deductive approach to analyze and triangulate multiple data sources, including teaching self-efficacy questionnaires, LCT knowledge tests, reflection essays, and semi-structured interviews.

The research study was conceptualized into three phases (i.e., course instruction and teaching experiences; follow-up questionnaire and interviews; triangulation) of a multistrand design and resulted in three major conclusions. First, plant science graduate students valued learning how to engage with K-12 audiences using active learning. Graduate students' expressed values of the following qualities: (a) how learners can apply knowledge to emerging agricultural issues, (b) how professors (i.e., graduate students as teachers) coach and facilitate, intertwining teaching and assessing, and (c) how to engage with learners actively by providing useful and timely feedback. Second, graduate students described field-based teaching experiences within formal and non-formal educational settings that helped them practice communication skills and develop their teaching self-efficacy. In this study, graduate students valued the following elements of a field-based experience: (a) participation in planning the experience, (b) selection of the learners by age and grade level demographics, and (c) multiple visits to teach the selected group of students. And third, graduate students described an enjoyment of teaching K-12 audiences and the K-12 experience was useful in preparing them to communicate science to technical and non-technical audiences. Graduate students' reflections of enjoyment were referenced with recognition to the sense of autonomy that the graduate students achieved throughout their learning experiences. Moreover, graduate students recognized the transferability of the knowledge and skills from the integrated learning experience for their academic and career endeavors. As graduate-level academic programs continue to adjust and adapt to prepare plant science graduate students to meet the needs of an ever changing society, the following implications are discussed: acquiring (LCT) teaching skills to communicate science literacy, benefits of K-12 audience field-based experiences, the opportunity to use a constructivist approach to assist learners in facilitating science outreach and implications for policy.

CHAPTER 1. INTRODUCTION

1.1 Introduction

Graduate students' motivation to share their knowledge and research with K-12 audiences as future scientists is informed by their beliefs and perceived value of science literacy outreach. Graduate training programs in academia integrate outreach teaching components to equip future scientists with a variety of communication skills in response to perceived graduate student needs and societal pressures (Laursen, Thiry, & Liston, 2012). Integrated graduate learning experiences provide graduate students with opportunities to network and collaborate with university peers to practice skills in communication, teaching, and mentoring. Communication, teaching and mentoring skills of scientists generally reflect science literacy through either a transmission of knowledge to the learner ("science for society view") or through engagement with the learner ("science in society view") (Mogendorff, te Molder, Gremmen, & van Woerkum, 2012, p. 745). The problem of scientists communicating science "science for society," instead of "science in society" with a K-12 audience could be addressed through examining graduate students' beliefs and values within educational courses focused on training to reflect upon outreach teaching experiences. Thus, individuals striving to accomplish a graduate degree in the sciences may reflect upon their beliefs and values of their professional development regarding three dimensions: (a) the personal graduate student experience, (b) career readiness, and (c) science literacy.

First, graduate students encounter a socialization process throughout their graduate experience that challenges their intellectual mastery, social acceptance of graduate life, and acceptance of a profession as presented in their department of academic study (Austin, 2002). Limited studies focusing on graduate students' (e.g., Graduate

Teaching Fellows [GTF] or fellows) motivational development throughout the experience illustrates the benefits and challenges for graduate students' participation (S. L. Thompson, Collins, & Metzgar, 2002), the self-efficacy of graduate students' teaching (S. Brown & Rich, 2007), and growth in professional socialization (Laursen et al., 2012). The benefits for graduate students to participate in outreach teaching experiences are often expressed through motivational accounts in National Science Foundation findings and reports (Mitchell et al., 2003). Likewise, challenges or barriers are attributed to graduate students' adjusting time schedules and graduation deadlines, recalling basic science concepts, or personnel conflicts with the teaching environment (Pickering, 2014). Similar to GTFs, graduate teaching assistants (GTAs) participate in few if any training sessions prior to beginning a university teaching experience. Mixed reviews of teaching self-efficacy studies with GTAs mostly detail support for increases in the quantity of teaching experiences to increase graduate teaching assistants' teaching self-efficacy (DeChenne, Enochs, & Needham, 2012). Graduate teaching fellows' reflections of teaching K-12 students describe an enhanced understanding of science concepts and the complexity of teaching science, especially using inquiry-based science teaching (S. L. Thompson, Collins, & Metzgar, 2002). Students were more motivated and performed at higher levels of achievement when teachers espoused higher levels of self-efficacy beliefs (Caprara, Barbaranelli, Steca, & Malone, 2006). In addition to knowing that self-efficacy beliefs are shaped early in a novice teachers' experience, variables examining efficacy beliefs in teaching science have the potential in predicting teaching behaviors in the classroom (Cakiroglu, Capa-Aydin, & Hoy, 2012). As graduate students progress through their post-baccalaureate education, professional development reflects the acquisition of knowledge, skills, values, attitudes, and interests graduate students may accept and internalize (Weidman & Stein, 2003).

With the understanding that graduate students follow the lead of their academic advisors and departmental colleagues, graduate students would likely develop qualities of faculty or scholars who support engagement (Connolly, Savoy, & Barger, 2010; Laursen et al., 2012). The transition from simply sharing scientific information to engaging the audience, regardless of whether it is in a non-formal setting or formal classroom, connects the science content to the developing process of potential application and further exploration for inquiry learning (Smith et al., 2013). Thus, graduate students are more likely to experience self-efficacious teaching when the outreach opportunities are meaningful and mutually beneficial through a developed understanding of the dynamic nature of the learner (Andrews, Weaver, Hanley, Shamatha, & Melton, 2005). And as scientists seek to connect to society through more personalized engagement activities, the recognition of using principles of Learner-Centered Teaching (LCT) has become widely acceptable in both instruction and research (McCombs, 2013). The paradigm shift to use principles of learner-centered teaching with adults and children situates the learner in authentic tasks to then gather knowledge, inquire, problem solve, and develop understanding (Knobloch, 2003; Polly & Hannafin, 2011).

Second, the unprecedented pace of science development thrusts graduate students into preparing to enter a future workforce very different than that of their predecessors (Leshner, 2007). In 2000, researchers seeking to acquire funding from the National Science Foundation (NSF) were required to develop projects in accordance with the Broader Impacts Criterion mandate (Kim & Fortner, 2008). The mandate evaluates proposals' intellectual merit of the proposed activities in conjunction with the broader impact of the outreach to members of society, thus emphasizing the importance of scientists disseminating research (Kim & Fortner, 2008; March, n.d.). The Graduate Teaching Fellows in K-12 Initiative was implemented by NSF to increase science literacy through introducing outreach education to young scientists in Science, Technology, Engineering, and Math (STEM) graduate programs. Previously conducted studies on preparing graduate students for outreach and teaching experiences focused on: (a) the benefits of the outreach program for the K-12 audience (DeGrazia, Sullivan, Carlson, & Carlson, 2001; Goldberg, Grunwald, Lewis, Feld, & Hug, 2012; Jeffers, Safferman, & Safferman, 2004; Suescun-Florez, Iskander, Kapila, & Cain, 2013); (b) the strengthening of relationships between universities and K-12 schools (Kim & Fortner, 2008; Luedeman, Leonard, Horton, & Wagner, 2003); (c) the techniques of teaching science (Gardner & Jones, 2011); (d) the process of how to teach inquiry-based learning (Luedeman et al., 2003; Wilhelm, Xiaobo, & Morrison, 2011); (e) an enhanced understanding of science content (McBride, Brewer, Bricker, & Machura, 2011); and, (f) the improved teaching and communication skills for graduate students (Calder, Brawley, & Bagley, 2003; Feldon et al., 2011; B. L. Grant, Liu, & Gardella, 2014; Laursen et al., 2012; Luft, Kurdziel, Roehrig, & Turner, 2004; McBride et al., 2011).

Finally, novice scientists not only face the historic "publish or perish" academic pressures, but also a developing societal responsibility to extend communication of their findings beyond research journals to policy makers and the general public (Smith et al., 2013, p. 1). The proliferation of science information and news continues to increase through advancements of technology via mass media outlets, thus necessitating the combined efforts of scientists and educators to advance science literacy (Besley & Tanner, 2011). A majority of online users (87%) utilize the Internet as a research tool to examine science concepts (Horrigan, 2006). Future scientists face a widening gap between scientists and society as science data is dumped into mainstream society in what is referred to as "the science deficit model of the public" (Smith et al., 2013, p. 1) with the hope that the general public would accept and understand the information at face value. However, a mere 17% of adults in the United States and comparatively equal or less worldwide are considered scientifically literate (Miller, 2004). It is important among industrial nations to have citizens and policy leaders that are scientifically literate to understand technological revolutions, scientific discoveries, and complex global challenges (Mackey & Culbertson, 2014). As such, improving the effectiveness of preparing scientists to engage with the public has spurred allocations of grants to assist in the creation of training programs and outreach opportunities for science educators, graduate students, and scientists.

1.2 Statement of the Problem

Scientists develop beliefs and values with regard to how they engage with non-scientists in science-related topics and issues. A growing strength of awareness within the scientific community illustrates the belief that it is important for scientists to communicate their knowledge in ways that are accessible to the general public, and are able to do so (Burchell, Franklin, & Holden, 2009). This "science in society" (Mogendorff et al., 2012, p. 745) view involves scientists continually adapting their conversations with non-scientists, which can result in one better understanding and relating to the other's perspective. Other scientists, however, do not develop these beliefs and expertise. Instead, they hold a "science for society" (Mogendorff et al., 2012, p. 745) view, whereby, they do not expect the general public to understand scientific work or do not believe it is necessary. As a result, they do not work to connect science with the daily lives of non-scientists. The situation of scientists resisting or having the inability to communicate scientific information in ways that can be understood by non-scientists is a concern, because it impedes an advancement of society's general science literacy. Scientists intending to advance science literacy with K-12 audiences may be able to engage K-12 audiences through strategies reflecting the "science for society view." The major problem of this study, therefore, is to examine how learner-centered teaching approaches enabled scientists to engage non-scientific K-12 audiences with scientific knowledge, and whether scientists-in-training value a science in society versus a science for society view.

1.3 Significance of the Study

This study was deemed important because of four predominant reasons. First, this study extends the examination of developing graduate students as professionals in the specific field of plant sciences with engagement strategies. Second, the study introduced the examination of career development of plant science graduate students with acquiring and practicing learner-centered teaching skills. Third, the study examined the holistic experiences of graduate students in time-condensed university outreach and engagement experiences with K-12 audiences. Fourth, the study examined graduate students' motivation to learn engagement strategies for outreach to society in addition to their graduate career focus.

1.3.1 Professional Development of Plant Science Graduate Students

Programs to train graduate students interested in studying in the varying fields of plant science differ across philosophies of preparing future scientists. Specifically, plant breeding programs preparing graduate students have fundamentally focused heavily on educational content as applied to developing cultivars, germplasm enhancement, and breeding research (Bliss, 2007). Aside from the typical focus on scientific knowledge and skills, a Delphi study found an uncertainty among programs preparing graduate students to meet diversified needs of future plant breeders (Repinski, Hayes, Miller, Trexler, & Bliss, 2011). Several of the highlighted needs related directly to graduate students acquiring field experiences and debating the value of obtaining communication and mentoring skills outside of a focus on an educational career track.

1.3.2 Acquisition of Learner-Centered Teaching Strategies

Graduate teaching experiences are highly structured and repetitive to ensure the successful delivery of knowledge toward undergraduate audiences versus an equally important developmental experience for graduate students (Austin, 2002). Learner-centered teaching enables facilitators to use a variety of learning approaches to assist the learner in successfully acquiring knowledge or skill (Weimer, 2013a). The process of facilitating a learner-centered activity promotes deep reflection, analysis, and forward thinking as an expert to engage the learner to inquire (J. Thompson, Licklider, & Jungst, 2003). Through this study, the researcher can describe the graduate students' perceptions of using learner-centered teaching strategies (Knobloch, 2008) as an approach to disseminating plant science research and engaging with others within learning experiences. Likewise, this research will provide a basis for educating agricultural graduate planning committees for the beneficial development of learner-centered teaching skills by plant science graduate students, thus, enabling plant scientists to emulate outreach training for future generations.

1.3.3 Time Barriers to Training Graduate Students

Graduate student scientists (including GTFs & GTAs) in GK-12 teaching programs spent varying times developing, practicing, and facilitating science activities with cooperating teachers and K-12 students (Mitchell et al., 2003). Reflections of GK-12 teaching experiences detail conflicting judgments by graduate students and supervising faculty in terms of teaching time commitments competing with research priorities (S. L. Thompson, Collins, Metzgar, Joeston, & Shepherd, 2002). Unlike semester or year-long GK-12 teaching programs, the experiences of the graduate students within this study were condensed to maximize graduate students' exposure to and proactive of learner-centered teaching approaches while minimizing the extensive time commitment negatively described in other programs.

1.3.4 Motivation for Outreach

Graduate students completing communication courses or workshops for outreach are able to craft statements of knowledge to inform the public or policy makers, most often referring to specific scientific issues (Besley & Tanner, 2011). Conversely, learner-centered teaching opportunities actively engage the teacher (i.e., graduate student) with the learner to facilitate critical and creative thinking about the outreach teaching concepts and activities (Cornelius-White, 2007). Previous studies of graduate students' experiences in STEM outreach provide a general summary of challenges and barriers as related to a specific experience; however, this study examines graduate students' beliefs and values in communicating scientific knowledge to K-12 audiences in an era of dynamic information overload. Thus, describing the motivations of plant science graduate students at a land-grant university with assistantship funding support from private industry stakeholders may provide greater understanding of graduate students' future intent to participate in outreach and advance science literacy.

1.4 Purpose of the Study

Graduate students have been trained to participate in outreach experiences to disseminate their research to a K-12 audience, yet little is known about plant science graduate students' science literacy outreach teaching beliefs and values. Particularly, it is important to describe the professional development of graduate students in regards to specific training. Training was offered as two college credit courses facilitating learner-centered teaching strategies to engage K-12 students with agricultural research content. The purpose of this mixed methods study was to describe the outreach teaching beliefs and values of plant science graduate students after receiving outreach training. The training consisted of learning and practicing learner-centered teaching strategies with the focus of disseminating research as science literacy to a K-12 audience.

1.5 Research Questions

1. What knowledge of LCT content did plant science graduate students' possess before and after the two-credit experience?

2. What beliefs and values do plant science graduate students express during and after participation in an integrated two-credit college pedagogical learning course and K-12 outreach experience as expressed through the following sub-questions?

   (a) What were graduate students' teaching self-efficacy scores prior to the experience?

   (b) What were graduate students' self-reflected post-teaching and retrospective pretest ratings for demonstrating LCT concepts, planning, learning, instruction, and environmental teaching domains?

   (c) What beliefs and values did students reflect upon and describe in their reflection essays?

3. Upon completion of the integrated graduate student training experience, what beliefs and values did graduate students describe from the K-12 experience regarding personal graduate experience, career readiness, and science literacy?

1.6 Assumptions of the Study

The researcher assumed that graduate students completed all class assignments individually and as a member of a team when specified by course instructors. In addition, the researcher assumed the answers supplied by graduate students were honest, viable, and reflective responses in relation to the specific questions regardless of the method of delivery (i.e., written or oral).

Positivism served as the paradigm for the mixed method design of this study (Hyde, 2000). A deductive approach to conduct the research with the inclusion of mixed methods enabled the researcher to focus the lens of multiple theories and guide the study while using multiple measures of the plant science graduate students' beliefs and values. Triangulation of the sources was important to minimize error and provide a view of the participants and their experiences with regard to multiple theories. The study was conducted with intent for objectivity as the researcher's biases were minimized through multiple procedural methods. Thus, the objectivity of the study's mixed methods research reflected the use of a deductive theoretical framework, data collection and multiple coding analysis with triangulation to observe motivational beliefs of plant science graduate students.

1.7 Definitions of Terms

Agriculture: "activities concerned with the production of plants and animals, and the related supplies, services, mechanics, products, processing and marketing" (Burton, 2009, p. 768).

Attainment Value: "personal importance attached to doing well on, or participating in, a given task" (Eccles, 2005, p. 109).

Cost Belief: "perceived negative aspects of engaging in the task" (Wigfield & Eccles, 1992, p. 16).

Descriptive Coding: summarizes content utilizing single words or phrases (Saldaña, 2013).

Educational Philosophy: "ideas and beliefs that guide teachers' actions and provide a framework for thinking about educational issues" (Eggen & Kauchak, 2004, p. 197).

Holistic Coding: an unrestricted "lumping" of qualitative data surmised to represent the overall theme of the selected data (Saldaña, 2013, p. 142).

Intrinsic Value: "the enjoyment people experience when doing a task" (Wigfield & Eccles, 1992, p. 16).

In Vivo Coding: "a word or short phrase derived from the actual language of the participants as found within the qualitative data" (Saldaña, 2013, p. 91).

K-12 Outreach: outreach is teaching and research outside of an organization that directly benefit the public (Laursen, Liston, Thiry, & Graf, 2007). Kindergarten through twelfth grade is the directed audience.

Learner-Centered Teaching (LCT): is "a broad teaching technique that utilizes active learning instead of lectures, holds students responsible for their learning, and uses self-directed and/or group collaboration/cooperation in learning. It is teaching that mainly focuses on the individual students' heredity, experiences, perspectives, backgrounds, talents, interests, capacities, and needs" (McCombs & Whisler, 1997, p. 9).

Learning: "the 'acquisition of knowledge', or perhaps the development of skills in the application of already existent knowledge" ("Learning," 2006, p. 123).
Teacher-Centered: a "formal, controlled, and autocratic instructional style which assumes the learners are passive. Teacher-centered teaching styles are consistent with the

western philosophies of idealism, realism, and the educational philosophies of liberal and behavioralism" (Fries, 2012, p. 3).

Motivation: "a continuum ranging from a motivation that is autonomous, originating within the self, to one which is controlled and stems from outside pressure" (Milyavskaya & Koestner, 2011, p. 388).

Pedagogy: is "the act of teaching, and the rationale that supports the actions that teachers take. It is what a teacher needs to know and the range of skills that a teacher needs to use in order to make effective teaching decisions" ("Pedagogy," 2008, p. 147).

Provisional Coding: "a pre-established set of codes prior to a selected phase of data analysis" (Saldaña, 2013, p. 144).

Reflexivity: "a way of emphasizing the importance of self-awareness, political/cultural consciousness, and ownership of one's perspective" (Patton, 2002, p. 64).

Science Literacy: is "the knowledge of useful science for helping people solve personally meaningful problems in their lives, directly affecting their material and social circumstance, shaping their behavior, and informing their most significant practical and political decisions" (Feinstein, 2011, p. 169).

Teaching: "to (teach), and its irregular past participle (taught), go back to Old English, with the meaning to show, to instruct, to impart knowledge. This implies another person, or other people, who are being instructed. Teaching cannot be carried out without learners – whereas learning can be carried out without teachers" ("Teaching," 2008, p. 189).

Teaching Philosophy: "the teacher's approach to teaching the student in the classroom" (Rodrigues, 2009, p. 2).

Utility Value: “how a task fits into an individual’s future plans, also connects to personal goals and sense of self” (Wentzel & Wigfield, 2009, p. 58).

View: an individual’s idealistic stance on a specific issue as guided by their philosophical beliefs (Harsanyi, 1995).

1.8 Delimitations of the Study

Through reflexivity, the role of the researcher was monitored to provide transparent bias brought to the study and to control the threat of bias within the study. Qualitative researchers observe and interpret data from their perspectives of the phenomenon under study (Patton, 2002). Throughout the years of teaching, the researcher has prepared future educators through student teaching programs aligned with the researcher’s high school classroom. The researcher’s passion to prepare teachers was evident throughout the program by the willingness to provide support outside of the classroom teaching responsibilities. The researcher’s personal interest in the participants’ success in the program was identified and controlled through weekly reviews of data coding and analysis with the researcher’s advisor. Additional reviews of data summaries were discussed with members of the researcher’s graduate committee. Similar to the graduate students in the study, the researcher shared a passion for agriculture and agricultural literacy. Thus, this experience may be unique due to the interaction between the researcher and the study participants.

This study only explored the experiences of graduate students who participated in the educational courses implemented for the Partnership for Research and Education in Plant Breeding and Genetics grant project at Purdue University. Multiple attempts were made to locate and contact selected participants for the interview. As such, the small number of individuals interviewed from the program may reflect personal bias that is unique to their experiences and backgrounds throughout their graduate program. The purposeful sampling used to select participants was designed to provide an in-depth collection of data, yet was reflective across the experiences of the graduate students. As each of the graduate students in the study may have different academic advisors, it was important to elicit students' responses with the caveat of imposed motivation derived from their academic advisors or department personnel. When this influence was identified, the researcher probed for additional personal experiences to support the statements. It was important to recognize the graduate students' novice skills and potential variable ratings with the teaching rubrics. While all graduate students completed the same rubric, the students may have viewed their personal ratings different than their peers. There was no training or calibration on how to use the rubric to increase inter-rater reliability. The graduate student's observations may also vary from ratings by an education expert. As such, graduate students may have marked their self-ratings higher than an expert observer because they were novices and were being graded for the course.

The role of triangulation of data and an audit trail were utilized to substantiate the findings within the unique experiences of the participants and provide dependable conformability of summarized findings. Throughout the study, participants were encouraged to share their responses without identifiable influence of the researcher. Attempts were made to communicate with students with methods conducive to eliciting trustworthy responses about their experiences. This study may not be generalizable beyond the scope of the participants' educational experiences and similar outreach training.

CHAPTER 2. REVIEW OF LITERATURE

2.1 Introduction

The training of scientists to communicate or conduct outreach through teaching experiences remains a focal point of federally supported grants, university, industry, and community partnerships, as well as graduate preparation programs (Andrews et al., 2005; McBride et al., 2011). While degree coursework based in theory and research methods may be similar across universities and colleges, not all graduate programs prepare students for many of the auxiliary responsibilities they will face in their future duties in academic life (Solem, Foote, & Monk, 2009). Research in educational instruction continues to pressure higher educational institutions to examine the structure and delivery of courses to provide significant learning experiences at all levels of instruction in the classrooms (Fink, 2003). Likewise, graduate students as learners and teaching assistants encounter a variety of teaching strategies and learning experiences throughout their graduate experiences.

The first section of this chapter serves to explain the *conceptual framework* of related constructs that detailed how plant science graduate students' coursework integrated translating their research with facilitating learner-centered teaching lessons with K-12 audiences. The second section of this chapter discusses the *theoretical framework* used to describe the graduate students' experiences and the essence of their experience. The third section of this chapter reviews the *current literature* of related studies on preparing novice scientists to navigate their career readiness for current and future academic responsibilities, such as outreach initiatives.

2.2 Conceptual Framework

The conceptual framework for the study encapsulated the relationship of the graduate students' personal factors within an identified environment and the observed and self-reflected associated behaviors. These three focal points collectively echoed the components or factors of Albert Bandura's (1986) triadic reciprocal determinism model: personal, environmental, and behavioral (see Figure 2.1). Specifically, graduate student personal elements such as previous teaching experience were reflected within Bandura's personal factors. The training within learner-centered teaching was reflected within the environmental factors. And, graduate students' reflections of their teaching performance were reflected as behavior factors. In this study the graduate students' elements of motivation to do outreach was recognized as a holistic view of the extended behavior factor. The following sections describe each of the sections within the conceptual framework and the relation to Bandura's model.

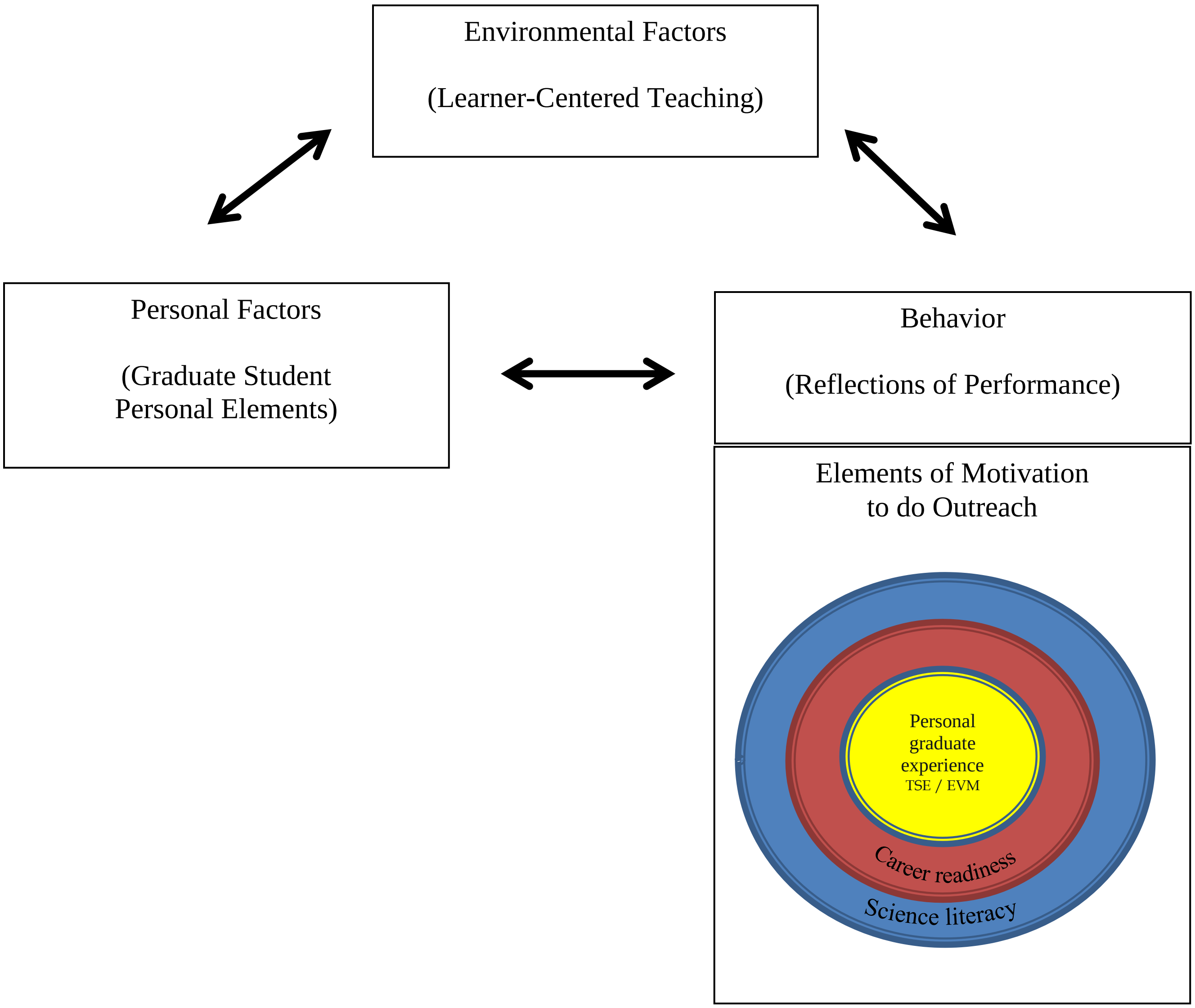

Figure 2.1 Bandura's Model of Triadic Reciprocal Determinism with Corresponding Study Elements

2.2.1 Social Cognition

Graduate students entering graduate programs of study have collectively encountered a variety of educational and life experiences. The various parts of the conceptual framework signify the factors of Bandura's model with this study's closely related elements. The framework illustrates the graduate students' process to make sense of the learning they encountered prior to and after the experience.

2.2.1.1 Personal Factors: Graduate Student Personal Factors

Students enter graduate school with diverse backgrounds and experiences. The graduate students make cognitive decisions and actions to "construct reality, self-regulate, encode information, and perform behaviors" throughout their developmental process leading up to, into, and throughout graduate school (Pajares & Usher, 2008, p. 392). Students utilize this cognitive reasoning to determine actions beyond that of a mere reaction to simple observations of the environmental and social factors surrounding them. The continual reflection and decision making can be examined using Bandura's psychological model of triadic reciprocal determinism. The triadic model reflects personal factors (such as attitudes and cognition) in relation to behaviors and the social environment (Bandura, 1986). In this model, the central focus is the individual's perception of how these three areas interact and affect future choices, feelings, and actions.

A close examination of the personal factors of the triadic model includes recognizing the individual's cognition or understanding of the affects intertwined with the decision process. Bandura's view of learning included an observational component referred to as modeling. Modeling has been distinguished through three distinct observational effect results (Bandura, 2006). The first describes the initial introduction to a novel response which presents the observing individual to determine how and when to replicate in the future. The second includes an element of self-judgment by the observing individual, thus attaching a negative or positive feeling associated with the resulting behavior. These behaviors may be recognized as inhibitory or disinhibitory effects (Bandura, 2006). And third, it is possible that the individual may have simply been socially cued by others in the environment. The instructors of the courses within this study used modeling as a teaching tool within the environmental section (i.e., the learner-centered teaching element).

The model of triadic reciprocal determinism forms the foundation for social cognitive theory (Bandura, 1986). According to this theory, the development of the individual is initiated through personal proactive actions based upon a set of self-beliefs (Pajares & Usher, 2008). An individual refers to these self-beliefs to evaluate and respond to personal thoughts, feelings or actions. The individual uses self-reflection to determine a sense of understanding or regulation for future actions based upon previous experiences. The capacity that an individual ascribes to personal capabilities for specific future actions is often studied within the self-efficacy belief(s) of the individual within a specific context. In this study, the specific context of self-efficacy was focused on graduate students within teaching experiences with K-12 audiences. Teaching self-efficacy has been documented as a method of examining an individuals perceived ability to teach in relation to the behaviors that are displayed in the classroom (Tschannen-Moran & Hoy, 2007). Teaching self-efficacy was utilized in this study to describe the motivation of graduate students' beliefs in their own teaching abilities with a K-12 outreach experience. Teaching self-efficacy will be further discussed later in the theoretical framework.

2.2.1.2 Environmental Factors: Learner-Centered Teaching

The focus on student learning is an important aspect of graduate studies (Huba & Freed, 2000). Students in higher education are often instructed using lecture-style presentations (Tapscott & Williams, 2010). The identification and development of the curricula to guide students in non-education degree programs to teach, however, continues to challenge graduate programs in higher education (Darling-Hammond, 2010). The transition to a learner-centered approach to teaching requires the redirection of the teacher as a facilitator of learning versus the disseminator of knowledge (Doyle, 2011). Graduate students may recognize aspects of learner-centered teaching from experiences in their youth. Learner-centered is defined as " the perspective that couples a focus on individual learners (their heredity, experiences, perspectives, backgrounds, talents, interests, capacities, and needs) with a focus on learning" (McCombs & Whisler, 1997, p. 9). Huba and Freed identified and examined eight hallmarks of learner-centered teaching:

> (a) learners are actively involved and receive feedback; (b) learners apply knowledge to enduring and emerging issues and problems; (c) learners integrate discipline-based knowledge and general skills; (d) learners understand the characteristics of excellent work; (e) learners become increasingly sophisticated learners and knowers; (f) professors coach and facilitate, intertwining teaching and assessing; (g) professors reveal that they are learners, too; and, (h) learning is interpersonal, and all learners (students and professors) are respected and valued (Huba & Freed, 2000, p. 33).

The hallmarks distinguish actions of both the learner or student and the teacher.

Similarly, Weimer (2013a) distinguished five key changes in practice when implementing the learner-centered teaching approach: (a) role of the teacher, (b) balance of power, (c) function of content, (d) responsibility for learning, and (e) purpose and processes of evaluation. The practical side to these guidelines and other texts on the topic of LCT is the intent to assist educators with developing a learning environment that embraces the student as an engaged learner. Engaging learning experiences through role-playing, debates, case-studies, problem-based learning, or service learning enable students to explore and learn through the experience versus the "dumping of knowledge" (Fink, 2003).

Faculty play a critical role at universities in developing a culture for undergraduates that foster learning (Umbach, 2005). Accordingly, preparing future faculty with an understanding of how people learn has become a focus of revisions to instruction within professional development courses and activities (Trautmann, 2008). The previous focus of teacher-centered instruction in professional development courses has been progressing to include learner-centered instruction (Huba & Freed, 2000). Weimer (2013b) suggests that instruction should include both static lecture and engaging learning experiences to achieve positive student outcomes. In a meta-analysis, Cornelius-

White (2007) concluded there was an above average association between learner-centered teacher variables and positive student outcomes. It is important for future faculty to be able to help students develop higher-level thinking or critical thinking skills while retaining knowledge. Graduate students working toward becoming future faculty should take part in developing engaging learning experiences. Individuals creating significant learning experiences utilize the learner-centered paradigm of teaching as the core focus of development, facilitation, and evaluation (Fink, 2003). However, a resistance to learner-centered teaching approaches are varied and may align with the complex nature of participating in a learning experience that is unrecognizable (Weimer, 2013a). The graduate student who is learning through the process of a learner-centered class may hesitate in initiating an acceptance of the approach due to the mere lack of experience in the fundamental planning of his or her own class in the near future. An understanding of how plant science graduate students navigate these unchartered waters using learner-centered teaching was not found during this review of the literature. However, the transition in general for faculty or teachers using learner-centered instruction and their students within the classroom has been documented as “the bumpy road” for both teachers and students (Felder & Brent, 1996, p. 43). Felder and Brent (1996) use the phrase “bumpy road” to symbolize the awkward and challenging transition from teacher-centered instruction to student-centered instruction. Thus, in this study it was important to recognize, include, and further examine plant science graduate students who had similar comprehensions and understandings of adjusting to using learner-centered teaching.

2.2.1.3 Behavior: Reflective Method

Reflective activities and reflection practices are common components of adult learning. Individuals studying to become medical doctors at Harvard University completed reflective training courses in small groups. The critical reflective activities encouraged future doctors to evaluate their tasks and skills as medical practitioners in relation to their beliefs and values throughout the learning experience (Branch Jr., 2010). In teacher preparation courses, reflection has been viewed with multiple areas of emphasis. Matthew (1998) emphasized how the focus of reflection practices can result in different summaries through three common foci: (a) distinguishing the general use of reflection according to a set of desired teaching behaviors, (b) the reflection as related to a specific context with a skilled practitioner's related experiences, or (c) a holistic view of influences outside of the initial experience, thus including moral and ethical constructs to frame the experience in its entirety. The novice teacher can use the process of answering directed questions or self-developed questions to advance reasoning and decision making skills to aid in becoming a reflective professional (Pedro, 2006). The reflective process may involve a personal reflective writing or an oral reflective discussion with peers. Writing was determined to be a productive method of reflection for learning experiences (Clouder, 2000; Matthew, 1998; Pedro, 2006), while group reflections have fostered personal and professional development for science-based instructors (Baird, Fensham, Gunstone, & White, 1991).

The interconnected layers of the (a) personal graduate experience, (b) development for career readiness, and (c) the perception of teaching to engage in science literacy with K-12 students was depicted as the holistic reflection from graduate students. This part of the conceptual framework illustrates the selected elements of motivation to do outreach. The selection of these elements was representative of three areas designated as focal points of graduate students' performance development. Moreover, each section can be related to the specific motivational constructs of expectancy value motivation as further defined within this study's theoretical framework.

2.2.1.3.1 Personal Graduate Experience

Professors in higher education can elicit stories from personal graduate student experiences that reflect a range of emotions from tribulations, successes, and some failures. It is these personal experiences that define the learning experience, which molds the new academic professional into the future faculty member and researcher of tomorrow. A research study funded by the Pew Charitable Trusts and the Spencer Foundation focused on examining the lives of 99 graduate students over the course of their graduate experiences. Personal graduate student experiences were described within three themes from the study: (a) graduate student tension to adapt to values displayed in their higher education setting, (b) “implicit and explicit” desire for support, and (c) the ambiguity of priorities within an academic setting (Nyquist et al., 1999, p. 19). The study was conducted with several of the graduate students residing at Research 1 land-grant universities. The Carnegie Foundation for the Advancement of Teaching previously referred to Research 1 universities as those institutions that had a high focus on research and granted a large number of doctoral degrees across a variation of programs (McCormick & Zhao, 2005). The study suggested the continuation of examining the personal graduate experiences of students at land-grant universities with a research focus. The self-reflections within the study included summaries expressing the values and beliefs of graduate students throughout their programs. A few key findings included: (a) a need to expand and define the role of mentoring and service in regards to scholarly life, (b) reform in preparing graduate students for the professorate through multiple avenues, (c) adjustments to academy values, (d) mixed messages about teaching and research responsibilities, and (e) self-reflections described clearly the challenges faced by this small group graduate students in higher education. Self-reflection was noted as a valuable tool for graduate students to review and synthesize their experiences to promote professional development for teaching (Schussler et al., 2008).

2.2.1.3.2 Career Readiness

The continual growth of jobs in plant breeding provides a rich opportunity for graduate students to enter a variety of jobs within the plant science career field (Bliss, 2007). Graduate students rely on guidance and mentoring within their academic programs to prepare them for the requirements to successfully navigate their future plant science careers (Gepts & Hancock, 2006). Graduate students may decide early in their program to focus on a job in the private sector, which focuses primarily on a specific set of job skills, such as developing new cultivars and occasionally on mentoring colleagues. Or, they may aspire to acquire a job in the public sector that requires the employee to provide training or teaching as part of their job description, alongside their research responsibilities. Thus, graduate programs are challenged to provide educational experiences that develop graduate students with a breadth and depth of knowledge to be successful across a range of job descriptions (Bliss, 2007). Mentoring is an example of a job skill that has had a tradition of implementation after employment was obtained, but has gained recognition as a valuable relationship between advisors and graduate students in science fields (Pfund, Pribbenow, Branchaw, Lauffer, & Handelsman, 2006). And while mentoring is not an element focused on within this study, there are notable links between mentoring, teaching, and learning as components often jointly referred to when describing professional growth and development (Riley & Fearing, 2009). Moreover, 96% of graduate students participating in a K-12 outreach experience as members of the Science Squad reported career gains (Laursen et al., 2007). The career gains included: (a) clarifying and confirmation of career choice, (b) transferable skills and understanding, (c) career networking, and (d) resume enhancement. Current graduate students need a program with “rigorous thinking, originality, and versatility” (Koshland, 1994, p. 711) along with systematic and guided self-reflections of developmental growth with advisors in preparation for the multidisciplinary and interdisciplinary nature of future career environments (Austin, 2002).

2.2.1.3.3 Science Literacy

Scientists work in environments that promote the advancement of knowledge through science research. As this knowledge is introduced to individuals outside the scientific community, it is often observed as being disseminated through two polar opposite views (Mogendorff et al., 2012). The views have been distinguished by two mutually exclusive thoughts. Both views have acknowledged the need to share science with society. However, within the science in society view, there has been an additional push to extend science literacy through more of an engagement approach. The engagement approach recognizes, addresses, and provides a scaffolding of support throughout the process. Whereas, science for society tends to espouse the top down approach with little regard for the non-science communities' desire to understand (Mogendorff et al., 2012). The teacher-centered form of dissemination instruction would be characteristic of the science for society view. On the other hand, an LCT approach with teaching would be characteristic of the science in society view. Conversely, science literacy (aka, scientific literacy) encompasses an understanding of science as it is applied to decisions for daily life (Feinstein, 2011). The polar opposite views may have been developed due to the resistance of the methods of teaching within science. The early inception of teaching science within school curricula was challenging and was established as an inductive thinking subject versus the historically deductive humanities (DeBoer, 2000). As such, many proponents of science education for science literacy state "that science education can help people solve personally meaningful problems in their lives, directly affect their material and social circumstances, shape their behavior, and inform their most significant practical and political decisions" (Feinstein, 2011, p. 169).

Scientists are advancing their studies to reflect the interdisciplinary and multidisciplinary teams required to solve the ever complex and dynamic problems in society (Klein, 2001). Science literacy has also continued to shift and adapt to the change of societal pressures. Scientists encounter many of these pressures through advances in communication, emergence of an information age, and the growth of a worldwide economy (Hurd, 1998). Science organizations recognize that beyond the instruction of science teachers in public schools, scientists are continually encouraged to engage with public audiences. However, there is some debate as to whether scientists have received training to support a positive experience and personal motivation to extend their knowledge to the public through outreach (Leshner, 2007). New models for training scientists have evolved in a variety of disciplines to examine the outcomes of the programs' objectives to assist novice scientists with learning and practicing outreach skills (McBride et al., 2011). Aside from programs reviewing graduate student scientists' progress in achieving science outreach goals, few studies allude to the personal motivation of graduate students' progress within outreach training programs (Bledsoe, Shieh, Park, & Gummer, 2004; B. Grant et al., 2013; McBride et al., 2011).

2.3 Theoretical Framework

Motivational beliefs and values of plant science graduate students were examined through two theoretical lenses. Humanistic psychology provided the basis for studying these students' capabilities and potentialities (Schunk, Pintrich, & Meece, 2008). The expectancy value theory was used to distinguish the task value and expectancy of students' beliefs. Teaching self-efficacy was the focus of the graduate students' beliefs about their abilities with teaching. Collectively, these theories assisted in describing the motivational beliefs and values of plant science graduate students' motivation to share their research and science knowledge with a K-12 audience.

2.3.1 Expectancy Value Theory

Graduate students begin graduate programs with previous experiences in relation to their research areas (Russell, Hancock, & McCullough, 2007). The previous experiences may have contained a variety of affective memories, personal goals, perceptions of the difficulty of various tasks, and judgments of their competence with their abilities in a particular environment. Schunk et al. (2008) distinguished these variables into two specific subcategories within a section of a social cognitive expectancy-value model: task value and expectancy. Eccles and Wigfield (2002, p. 110) differentiate expectancies as the "beliefs about how one will do on different tasks or activities" from values as the "incentives or reasons for doing the activity." Expectancy encompasses a personal evaluation of selected goals, situated competence in regards to self-schemas, and a self-perception of the difficulty in the given task (Schunk et al., 2008). The personal evaluation of those collective thoughts influences the decision to attempt, continue or avoid a task as a task value is cognitively established by a person. For example, a graduate student selects a graduate program of study based upon interest in the subject content, previous enjoyment with activities related to subject content, and the potential career earnings by obtaining an advanced degree. As graduate programs are highly specialized around a specific content area, the graduate student's intrinsic value would likely be high. Likewise, a graduate student focuses intently upon the specific content area and may make decisions about time allocations in respect to the effect upon that focus.

Graduate students in plant sciences disciplines encounter a variety of tasks associated with their coursework, research, and assistantship responsibilities. The tangible tasks reflected throughout plant breeding literature revolve around the necessary courses and field-based research experiences for graduate students to become acculturated plant breeding or genetic specialists (Bliss, 2007; Gepts & Hancock, 2006; Repinski et al., 2011). The decision as to why a student should complete particular courses is obvious in relation to the tasks currently associated to a career goal. However, this decision may be ambiguous when the task, such as outreach, is considered less tangible.

Identified as self-regulated learners, graduate students continuously assemble goals based upon individual beliefs and self-concepts with the challenge of finding balance with their personal freedom (Pintrich, 1995). As graduate students are focused primarily upon the goal of achieving success with an advanced higher educational degree, their personal freedom is reflected by the choices with their behavior. Eccles and Wigfield (1995) suggested four components through which to examine achievement behaviors: (a) attainment value or importance, (b) interest or intrinsic value, (c) utility value, and (d) cost belief. The importance and utility value of outreach is reflected by plant science graduate students through forms of engagement as a part of the three-part mission of a land-grant university, specifically through Extension and engagement. Ryan and Deci (2000) emphasized the importance of the individual expressing intrinsic motivation in a learning context as it often results in high-quality creativity and learning. The cost belief may be a factor related to the forces encouraging the decision to undertake outreach teaching experiences or avoiding them. Collectively, observing these behaviors may provide a basis for identifying specific values that plant science graduate students express regarding their participation in outreach education to K-12 audiences. Likewise, graduate students participating in reflection writings of their program goals, personal values, and professional values may have gained a deeper consideration of their learning and understanding in a given situation.

2.3.2 Teaching Self-Efficacy

After sitting on the student side of the desk for most of their academic career, many graduate students begin to initiate teaching in the formal role as a graduate teaching assistant. Graduate students may begin to adapt their schemas of teaching based upon participation within various formal and non-formal teaching experiences. Throughout their experiences, graduate students may decide to adapt their behaviors due to observations in the classroom environment. The graduate students may also be personally affected by the teaching experience. These observations, decisions, and adaptations reflect a specific contextualized experience within the previously mentioned triadic reciprocal determinism model in the Social Cognitive Theory (Bandura, 1986). Bandura (1986) termed the judgment that people develop from their personal evaluations of their capability to learn or perform an action as their self-efficacy. Teaching self-efficacy is a an individual's self-perceived capabilities in a teaching environment (Tschannen-Moran & Hoy, 2007). The process of learning to teach may initially happen as a vicarious learning experience by which the graduate students observe the behaviors of their instructors or through enactive learning in which the graduate students engage in teaching activities with a group of learners (Schunk et al., 2008). The graduate students reflect upon their experiences within an environment and self-reflect on their personal attributes to develop judgments about their potential abilities in a similar context. The term teaching self-efficacy is further distinguished by the specific context of the teaching action that takes place in an environment and the resulting behaviors (Goddard, Hoy, & Hoy, 2004). Mastery experiences, verbal persuasion, vicarious experiences, and physiological arousal are the four major influences on teaching self-efficacy (Tschannen-Moran & Hoy, 2007).

Goddard et al. (2004, p. 4) stated that "teachers' sense of efficacy is a significant predictor of productive teaching practices." Teaching self-efficacy of individuals in teaching environments were found to be higher when these individuals were involved with a mastery experience (Tschannen-Moran & Hoy, 2007). Individuals with higher levels of teaching self-efficacy were more likely to be organized and effectively planned (Goddard et al., 2004). By contrast, an individual who observes a modeling of the teaching activity by another is participating in a vicarious experience. A vicarious experience was noted to have a positive influence on a person's self-efficacy when the observer self-identifies with the individual modeling the behavior (Tschannen-Moran & Hoy, 2007). As such, Tschannen-Moran and Hoy (2007) suggested further qualitative research to examine the effects of vicarious experiences on novice teachers. Graduate students who are training to be scientists in plant sciences may not have much experience in teaching and would likely consider themselves to be novice teachers. Teaching self-efficacy studies vary across the literature. Several studies have focused on teaching self-efficacy of novice or experienced K-12 teachers in the field of science (Bleicher, 2004; Khourey-Bowers & Simonis, 2004; Ramey-Gassert, Shroyer, & Staver, 1996). Fives and Looney (2009) expounded upon the literature of teaching self-efficacy studies focused upon university faculty and graduate students. Among the findings of the study, individuals ranking themselves high with teaching self-efficacy also believed in a high collective teaching self-efficacy within their teaching groups and colleagues. Thus, graduate students in teaching assistant positions could potentially be influenced by the course instructor or advisor. Additionally, Fives and Looney (2009) determined a similarity of efficacy levels across individuals with similar professional levels and goals. In comparing the studies, the results reflected a summary of the potential relation of self-efficacy beliefs and outcome expectancy to motivation.

2.4 Scientists and Career Outreach

The positioning of agricultural programs at land-grant universities, the development of experiment stations and the formation of the Cooperative Extension Service have provided additional historical connections to early scientific outreach (Herren & Edwards, 2002). The following literature review has three sections that examine the issues with training scientists for outreach: (a) federal mandates and programs encouraging scientists to participate in outreach, (b) examples of university agricultural or life science graduate education outreach training programs focused on the prekindergarten through twelfth grade (PK-12) audience, and (c) supportive studies demonstrating the need to continue training future scientists to conduct outreach. The overarching themes from the three sections are then synthesized to designate how this study provides a holistic and integrated view of typical and narrowly examined components within graduate teaching experiences.

2.4.1 Federal Mandates and Programs

The National Science Foundation (NSF), the National Institute of Food and Agriculture (NIFA), the Agricultural Research Service (ARS), and the National Institutes of Health (NIH) [an agency of the U.S. Department of Health] have provided grant funding opportunities to pair their research interests with K-12 audiences. NSF provides federal funding through the National Science Foundation Act of 1950 "to promote the progress of science; to advance the national health, prosperity and welfare; [and] to secure the national defense" ("NSF in a Changing World," 1995, p. 1). Among the initiatives the Act authorized NSF to initiate and support science and engineering education programs at all levels and in all the various fields of science and engineering. Researchers responding to the NSF requests for funding proposals (RFPs) are strongly encouraged (if not stated as a requirement) to include impact statements that contain K-12 outreach as a part of their audience (Moskal & Skokan, 2011).

NSF provided funding for graduate teaching fellows in school environments from 1999 to 2011. Graduate students acted as content experts in classrooms to facilitate teacher and student development in advancing their knowledge of Science, Technology, Engineering, and Math (STEM) content and skills. NIFA replaced the Cooperative State Research, Education, and Extension Service (CSREES) in 1994 and is one of four agencies in the Research, Education, and Economics (REE) mission within United States Department of Agriculture (USDA). ARS, another agency in REE, serves as the chief scientific in-house research agency. The ARS division of outreach activities includes career outreach, congressional outreach, and global outreach in science. Each of these areas encompasses formal and non-formal education through agricultural contexts with the general public and specific audiences (United States Department of Agriculture, 2013). NSF, NIFA, ARS, and NIH extend grant opportunities for researchers to share career outreach and global outreach in science opportunities so that research scientists can disseminate their research to varied educational audiences.

The educational outreach conditions vary according to the Requests for Applications (RFAs) and across the mission statements for the various aforementioned agencies. All agencies provide detailed instructions for interested parties applying for grants; however, this process may be overwhelming to novice scientists. Novice scientists may not have yet established a network of professionals from which they can draw a team together for developing a large grant proposal (Lawrence, 2009). Novice scientists may also not yet be familiar with the particular buzz words or phrases that seasoned professionals know to include to be advanced to the next round of review. A year-long study focused on training graduate students to develop NIH grant proposals utilized writing coaches to scaffold and mentor the graduate students (Ding, 2008). Markedly, the study supported the need for graduate students to explore writing proposals directed beyond the usual research consumers. As such, universities offer training through either specific coursework or professional development sessions to assist new faculty and interested graduate students with developing successful grant proposals. Professional associations have made recommendations for novice scientists to work collaboratively with educational specialists to build an understanding for outreach educational requirements of NSF and other federal grant programs (Ammerman, 2004).

2.4.2 University PK-12 Graduate Outreach Training Programs

Programs to prepare scientists and university faculty to work with PK-12 audiences have developed a variety of program approaches with differing intervention durations. The professional development provided to graduate students and faculty varied by program in length of instructional time and pedagogical depth. As such, the following three programs provide a highlight of the varying intervention duration, program focus and depth of pedagogical instruction. The Ecologists, Educators, and Schools (ECOs) program at the University of Minnesota provided graduate students with year-long seminars, two intensive summer institutes, and a variety of professional development workshops in addition to their respective school residence placement (McBride et al., 2011). The Teaching, Research, and Industry Applications to Deepen Scientific Understanding (TRIAD) program at Middle Tennessee State University formed collaborative teams of graduate students, high school biology/chemistry teachers and biotechnology/biomedical industry partners. Through the TRIAD program graduate students assisted in the development of understanding how to apply classroom knowledge and skills to solve society's biological problems (Farone et al., 2013). The Science Squad program at the University of Colorado was formed by the Biological Sciences Initiative (BSI). The squad consists of graduate students that were selected through an application to develop and teach a series of hands-on science activities to a K-12 audience over the time of one year (Laursen et al., 2007).

Researchers have reported mixed program focuses and results from the graduate student teaching experiences. The development of skills and application of knowledge across K-12 graduate teaching experiences varied by program but reflected positive experiences with planning, implementation and reflection (Laursen et al., 2007; McBride et al., 2011). Leadership, communication and team building were the major focuses of the TRIAD program. Mitchell et al. (2003) distinguished similar program evaluation findings in their review of NSF graduate GK-12 teaching fellows programs. The findings included: (a) positive role models for students, (b) content knowledge gains for teachers, (c) improvement of K-12 school to university relationship, and (d) graduate students improving communication and instructional skills. The following three challenges were noted across these various programs. Graduate students struggled to balance their research interests with the demands of the teaching preparation and implementation. Graduate students valued the experience of teaching and the career mentoring opportunities. The sustainability of the programs due to funding concerns was a noted negative concern.

Dolan, Soots, Lemaux, Rhee, and Reiser (2004) interviewed a group of 16 professionals with genetic science academic foci and varying outreach experiences. The study resulted in a description of several successful outreach programs. The following describes a few of the characteristics and the strategies used to address program obstacles. Outreach programs with K-12 audiences are diverse across the country and such is the training to prepare graduate students to meet the various needs of differing academic programing within each state. Providing professional development and training for graduate students should include using existing educational resources and access to personnel with pedagogical expertise versus each scientist trying to continuously reinvent the K-12 outreach wheel (Dolan et al., 2004).

2.4.3 Continue Training Future Scientists

Funding for NSF graduate teaching fellowships known as the GK-12 program ended in 2011. The GK-12 program achieved the goal of providing models for K-12 schools and institutions of higher learning to adopt. The future training of graduate student scientists in K-12 schools continued with funding for these programs tied to new agendas for advancing sciences in specific contexts. B. Grant et al. (2013) detailed how an Interdisciplinary Science and Engineering Partnership (ISEP) formed a Science, Technology, Engineering, and Mathematics (STEM) program to incorporate graduate and undergraduate students in the professional development of teachers. A portion of the program provided experiences for teachers to use and develop inquiry science lessons in science labs, while graduate and undergraduate students provided facilitation for implementing advanced interdisciplinary inquiry-based science instruction (B. L. Grant et al., 2014).

Brownell, Price, and Steinman (2013) recommended institutions of higher education adapt and implement instructional courses for graduate students to develop communication skills to disseminate research to public audiences. Graduate student scientists are faced with educating science to a broader audience than previous scientists due to the advancement of access to science literacy beyond the scientific research community. McBride et al. (2011) suggested the need to change the current structure for educating student scientists. Courses should be designed to prepare students to be successful in dynamic and highly competitive environments as situated in real-world settings. Universities can leverage the engaging academic research components with outreach opportunities to provide students with a course transformed from job training into experiential learning (Whitmer et al., 2010).

2.4.4 Holistic and Integrative Approach

Across the presented literature, studies focused on single elements expressed in the conceptual framework, such as graduate teaching experiences. Many of the elements from within these single studies relate to a more holistic view. As such, several themes point toward a gap in a graduate student's holistic view of engaging in outreach with K-12 students. Graduate students' previous teaching experiences and training were determined to be positive influences in graduate students' development of teaching self-efficacy (Prieto & Altmaier, 1994). Likewise, graduate students in the role of teaching assistants that had prior teaching experiences with K-12 audiences were rated by college students as more effective than those graduate students with no experience (Shannon, Twale, & Moore, 1998). Recommendations to improve graduate teaching experiences included focusing on course planning, instructional strategies, and evaluation through concise instructional experiences that minimized university and departmental policy (Shannon et al., 1998). Beyond completing experiences and self-evaluations, graduate teaching programs should also provide opportunities for graduate students to receive feedback from their teaching peers (DeChenne et al., 2012).

The literature focused on professional development of plant breeding scientists predominately featuring recommendations to academic courses, lab instruction, and networking experiences with industry professionals, yet only slight comments were included about outreach to the public and non-existent references to K-12 audiences

(Bliss, 2007; Repinski et al., 2011). As federally funded programs continue to require outreach components within proposals for grants, scientists require professional development in engaging with the increasingly diverse public (Leshner, 2007). Learner-centered teaching techniques may be a method for plant scientists to develop an understanding of how to engage with K-12 students as recognized within engineering studies currently using active and inquiry learning (Jeffers et al., 2004). Likewise across the literature, the challenges to adapt current training programs to include engagement experiences described time constraints, yet lacked a description from graduate students about their utility value of the experience in retrospect to their cost belief. The researcher was unable to find studies which examined graduate students' reflections of outreach teaching experiences using an expectancy value motivation theory. Expectancy value motivation theory encompasses many of the concepts evaluated singularly across much of the literature. Page, Wilhelm, and Regens (2011) alluded to the continued research required to better understand the holistic experience of graduate students in K-12 outreach experiences. Currently, there is a gap in the literature with understanding the holistic motivational experiences of plant science graduate students engaging in outreach with K-12 audiences.

2.5 Summary

As graduate students are likely to encounter more diverse audiences than their predecessors, the need arises to not only explain their knowledge of science but engage their audience in a mutual educational discussion. Graduate students reflect upon experiences and modify motivations as they progress through their academic programs. The reflections assist the graduate students in self-evaluating their learning process and the decision to embrace actual performance. Likewise, learner-centered teaching has been recognized as an effective method of facilitating content to a diverse audience with varying ability levels (Huba & Freed, 2000). Accordingly, institutions of higher learning and government research programs are interested in evaluating the graduate students that participate in educational outreach training programs. As graduate students attempt new pedagogical activities, they review their teaching self-efficacy for completing the task. Teaching self-efficacy is the perception of capability an individual has when encountering a teaching environment. Individuals are also influenced by their observations of environments and the people. A reflection of the graduate students' expectancy and task value stems from how a graduate student self-regulates their decisions to utilize or complete various requirements within their programs. Chiefly, researchers continue to be interested in examining the motivation that graduate students develop as a result of participating in K-12 outreach instruction as a part of their academic program.

CHAPTER 3. METHODS

3.1 Introduction

The methods detailed in this chapter is divided into the following sections: (a) research design; (b) grant components overview; (c) study population and sample; (d) K-12 education training; (e) study instrumentation; (f) validity and reliability; (g) role of the researcher; (h) data collection; and, (i) data analysis. A descriptive, sequential mixed methods research design was used to guide the collection and analysis of data. The collection of data for this study was completed after participants concluded all activities for the academic requirements in the associated grant sponsored courses of study. The analysis of data for this study was completed sequentially according to three distinct phases.

3.2 Research Design

The researcher used a deductive approach with quantitative and qualitative methods to describe plant science graduate students' outreach teaching beliefs and values after learning and practicing learner-centered teaching strategies to disseminate their research as science literacy to a K-12 audience. The mixed methods research design for this study was developed using a sequential mixed methods design (Teddlie & Tasshakori, 2006). The research study was conceptualized into three phases of a multistrand design. A detailed version of the sequential mixed methods design for this study was provided in Appendix A. Quantitative and qualitative methods were used within each phase.

3.2.1 Phase One

The first conceptualization stage occurred within phase one. The first stage described the portion of the research questions focused on examining the experiential stage one items from quantitative and qualitative data. Phase one quantitative items included: (a) LCT knowledge pre and posttests, (b) teaching self-efficacy pre-questionnaires, and (c) self-reflected LCT post-teaching and retrospective pretests. Phase one qualitative items included: (a) reflection essays of a non-formal teaching experience, and (b) reflection essays of a formal K-12 teaching experience. The summaries from all the quantitative and qualitative data in phase one were summarized and synthesized to provide guidance in developing the interview questions and questioning probes for the follow-up interviews.

3.2.2 Phase Two

The second conceptualization stage occurred within phase two. The second stage described the portion of the research questions focusing on examining experiential stage two items with quantitative and qualitative data. The phase two quantitative item was the follow-up teaching self-efficacy questionnaire. The phase two qualitative item was the follow-up interviews. The semi-structured video interviews were conducted similar to a job interview for an academic position and lasted on average approximately 60 minutes. These findings were summarized within the second inferential state.

3.2.3 Phase Three

In the third phase, a meta-inference from the qualitative and quantitative findings from phases one and two were drawn together to examine four graduate students' outreach teaching beliefs and values in regards to components of the Expectancy Value Theory (theoretical framework): (a) attainment value or importance, (b) interest or intrinsic value, (c) utility value, and (d) cost belief. The meta-inferential phase within the mixed methods design was employed to triangulate the link between all inferential quantitative and qualitative data summaries in this study.

3.2.4 Quantitative and Qualitative Methods

Descriptive research as outlined by Neuman (2006) was used to depict specific motivational details of plant science graduate students. The quantitative methods of the study were focused on providing descriptive results to statistically answer corresponding research questions. The qualitative methods explored descriptions of the graduate students' motivation before and after their teaching experiences. The researcher used a deductive, theories-driven approach to guide the study's framework, data collection, and data analyses. A combination of survey methods and field observation methods (Jackson, 2009) were used within data collection. The qualitative data analysis was guided by the theoretical framework. The researcher then utilized multiple coding strategies within the qualitative data analysis to identify and describe when data reflected the selected motivational concepts within teaching self-efficacy and expectancy value motivation.

A role-ordered matrix by Miles, Huberman, and Saldaña (2014) was adapted into an engagement-ordered matrix. The data designated within the matrix was selected based upon the item or narrative as an over-all representation of the interviewee within a data source. The matrix sorted data for each interview participant in a row according to specific elements in the columns. The chart display permitted systematic comparisons across participants to examine similarities and differences within each motivational point of interest. The strength of this mixed-methods design was to corroborate and contrast findings about graduate students' motivations across varying data sources. Thus, the mixed methods research approach enabled the researcher to explore the descriptions of graduate students' K-12 teaching experiences according to the motivational framework of teaching self-efficacy and expectancy value motivation theory.

3.2.5 Institutional Review Board Approval

Purdue University's Internal Review Board approved the study #1301013139 on May 8, 2014 (Appendix B). An amended research protocol was approved on September 3, 2014 (Appendix C). Graduate students participating in the follow-up self-efficacy questionnaire within phase two received a five dollar gift card as a token of appreciation. Graduate students participating in the follow-up video interviews within phase two received a twenty-five dollar gift card as a token of appreciation.

3.3 Grant Components Overview

This study utilized data that was originally graduate students' class assignments for the pedagogical training portion of the Partnership for Research and Education in Plant Breeding and Genetics grant project. The program was funded under Agriculture and Food Research Initiative (Project No. 2010-85117-20607) from the USDA National Institute of Food and Agriculture. Graduate students completed a teaching self-efficacy questionnaire and a LCT knowledge pretest at the beginning of the first seminar course. Graduate students completed the LCT knowledge posttest at the conclusion of the two courses focused on engaging K-12 students. Graduate students completed a retrospective pre- and post-self-reflection rubric after completing their teaching experience. The first cohort of students completed a philosophy of teaching essay, which the second cohort did not complete due to adaptations by course instructors. After participating in the volunteer experience and the teaching of a class of K-12 students, both cohorts completed reflection summaries in essay form. The remaining data items consisted of participants revisiting the teaching self-efficacy questionnaire prior to participating in a follow-up semi-structured interview a year after the last student completed the teaching experience.

3.4 Sample and Cohorts

Graduate students in the grant project were demographically diverse in graduate programs of study, gender, race, and academic degrees (Ph.D. or Master's). A purposive sample of individuals was derived from the plant science graduate students completing all the required course assignments from the integrative learning experiences for The Partnership for Research and Education in Plant Breeding and Genetics project. The required course assignments included: (a) pre-teaching self-efficacy questionnaire, (b) pre-LCT knowledge assessment, (c) post-LCT knowledge assessment, (d) retrospective pre self-reflection rubric, (e) post self-reflection rubric, (f) teaching reflection, and (g) volunteer reflection.

The following two exclusion criteria reduced the number of graduate students in The Partnership for Research and Education in Plant Breeding and Genetics project prior to the start of phase one. First, graduate students who did not complete the K-12 teaching experience were removed from the participant pool. Second, an initial analysis of graduate students' reflection essays resulted in a list of participants who had limited understanding of the structure and context of the U.S. education system. These individuals were removed from the participants' interview list as their misunderstanding of the functional K-12 education system added an additional variable that was not the focus of this study and deemed a potential confounding variable. Thus, the purposive sample was used to identify plant science graduate students who completed all required assignments and demonstrated a basic understanding of the United States K-12 educational system.

The sample was divided into Cohort 1 and Cohort 2. For the beginning of phase one, participants *(n* = 17*)* were split into two distinct groups based upon their non-formal learning experience in the first course. The first group, referred to as Cohort 1 in this study, (*n* = 10) participated as volunteers in pre-established non-formal agricultural education engagement with youth at events sponsored by Purdue Cooperative Extension and Indiana FFA (also known as Future Farmers of America). These graduate students attended their choice of event as individuals. The second group of graduate students, referred to as Cohort 2, (n = 7) conceived, developed, and implemented a non-formal learning experience. These graduate students worked within teams to develop an interactive learning experience for youth and adults attending Purdue University's Spring Fest. Spring Fest is an engagement event by Purdue University to communicate and educate youth and adults from the state of Indiana. Academic departments, University service departments (e.g., Cooperative Extension Service, Purdue University Police), student cultural clubs, and social and honor fraternal societies engage youth and adults with learning activities. Similar to the first cohort, these students volunteered their time to engage with youth. Lastly, 17 graduate students received a letter (Appendix D) inviting them to complete a follow-up self-efficacy questionnaire and the potential to be invited to discuss their motivation to communicate plant science literacy through engagement experiences in an interview akin to a job interview. This email also contained the approved Research Participant Consent form (Appendix E) for participating individuals to sign and return to the researcher. The four individuals selected for the video interview portion of the study were identified through their ranking of exemplars to non-exemplars (science in society view vs. science for society view) from each of the two cohorts. The exemplars to non-exemplars ranking of graduate students was according to the results and findings from the first phase of analysis.

3.5 Participants' Demographics

The 17 participants in this study were graduate students in the plant sciences in a college of agriculture at a research-intensive, Midwestern, land-grant university. The participants received assistantship funding through The Partnership for Research and Education in Plant Breeding and Genetics project. A requirement of the grant was for graduate students studying within academic agricultural cohorts to participate in the implementation of integrative learning experiences. The Fostering Communities of Learning (A. L. Brown & Campione, 1996) model was designated as the educational learning system for the project by The Partnership for Research and Education in Plant Breeding and Genetics grant team. The FCL model directed the establishment of interactive activities with the intentional result of providing a self-consciously active and reflective learning environment. The formation of cohorts was utilized throughout their experience with various agricultural plant science programs. The cohorts for research activities within the grant project were composed of different compositions of graduate students in comparison to the cohort groups designated within this study.

Participants for the first phase of the study included 17 graduate students. The following characteristics described the 17 study participants, as self-reported by the graduate students. As shown in Table 3.1, the gender of the participants consisted of nine females and six males. As shown in Table 3.1, a majority of the participants in the first phase were doctoral degree (*N* = 13) seeking graduate students.

Table 3.1 Demographics of Graduate Students in Phases

Gender	Frequency	Degree sought	Frequency
First Phase *(N = 17)*			
Female	9 (53%)	Doctoral	15 (88%)
Male	8 (47%)	Masters	2 (12%)
Second Phase - A *(N = 15)*			
Female	9 (60%)	Doctoral	13 (86%)
Male	6 (40%)	Masters	2 (13%)
Second Phase - B *(N = 4)*			
Female	1 (25%)	Doctoral	4 (100%)
Male	3 (75%)	Masters	0 (0%)

The participants for the second phase of the study included four graduate students derived from the first phase participant group. The following characteristics described the four study participants completing the teaching self-efficacy questionnaire (see Table 3.1). As shown in Table 3.1, the gender of the participants consisted of nine females and six males. From those completing the post-teaching self-efficacy follow-up questionnaire, four were selected for the video interviews. The selection of two individuals from each cohort was based upon two factors: (a) completing the follow-up teaching self-efficacy questionnaire, and (b) the initial analysis from phase one. Thus, an individual was selected from each to represent an individual with science in society or science for society views.

3.6 K-12 Education Training

The graduate students completed 2 one-credit courses as required by participation in the grant program and in conjunction with normal graduate coursework. The courses focused on the preparation of graduate students to translate and communicate their science to K-12 audiences. The following is a summary of each course and the course specific activities.

The Plant Breeding Education and Outreach Seminar course (first course) was team taught by Dr. Neil Knobloch, Dr. Kiersten Wise, and Melissa Leiden Welsh. The course was divided into two 8-week segments. Dr. Knobloch and Melissa facilitated class during the first 8 week session. The course was taught using principles of learner-centered teaching. Students examined best practices that were grounded in effective teaching and learning for Extension and non-formal K-12 education. Students were taught strategies that promoted engagement in field-based and K-12 educational settings through Extension presentations and active learning plant science activities. All activities were conducted during a weekly, hour-long semester class. Course assignments included the following: (a) Learner-Centered Teaching Knowledge pre and posttests, (b) Teaching Self-Efficacy pre-and post-questionnaires, and (c) Philosophy of Outreach summary. The second cohort of students in this study did not complete a philosophy of outreach summary. The first cohort of students completed their volunteer experience during the semester they completed this course. The syllabus for this course for Cohort 1 is listed in Appendix F and for Cohort 2 is listed in Appendix G.

The Plant Breeding Research for the K-12 Outreach course (second course) was team taught by Dr. Neil Knobloch and this study’s researcher. The course was taught using principles of Learner-Centered Teaching. The first four weeks of this course’s activities were conducted during weekly, hour-long classes. The remainder of the course activities was specific to the individual student and conducted under the guidance of the project's graduate teaching assistant, the researcher. Prior to starting her doctoral program, the researcher taught 12 years as a certified Family and Consumer Sciences classroom teacher. This professional experience helped her facilitate individual lesson preparation assistance for the graduate students along with scheduling teaching experiences in Indiana school corporations. Course assignments included the following: (a) Professional Development Plan, (b) student's current research based K-12 Lesson Plan, (c) Retrospective pre/post Teaching Assessment Rubric, (d) volunteer Non-formal Teaching Experience Summary, and (e) Formal Teaching Experience Summary. The syllabus for this course for Cohort 1 is listed in Appendix H and for Cohort 2 is listed in Appendix I. As shown in Table 3.2, the locations for the formal teaching experiences were varied according to school location, grade of students, and class enrollment sizes.

Table 3.2 Formal K-12 Teaching Experience Locations

School Name	No. of Graduate Students	Grade of Students	Class Enrollment	School Location
Tri-County High School	1	10-12 grade	18	Wolcott (rural)
James Cole Elementary School	3	2-3 grade	18	Stockwell (rural)
Murdock Elementary School	3	3rd grade	15	Lafayette (rural)
Tri-County High School	1	10-12 grade	25	Wolcott (rural)
Fredrick Douglass Elementary School	2	3rd grade	28	Indianapolis (urban)
Thomas Carr Howe Community High School	2	9-12 grade	17	Indianapolis (urban)
Local Boy Scouts Troop	3	10-12 grade	4	West Lafayette (rural)
Tecumseh Middle School	1	8th grade	28	Lafayette (rural)
Thomas Carr Howe Community High School	1	9-12 grade	17	Indianapolis (urban)
Total	17		170	

3.7 Study Instrumentation

The researcher utilized multiple instruments within the mixed methods study. Quantitative and qualitative instruments were selected to provide multiple measures of graduate student participants' beliefs and perceived values throughout and after the teaching experiences. The following sections detail the study instruments within quantitative and qualitative methods.

3.7.1 Quantitative Instruments

In the study, quantitative instruments recorded participants' responses through a rating scale for selected responses to directed questions. The instruments reflected a variety of characteristics within the theoretical frameworks of teaching self-efficacy and expectancy value theory. The quantitative instruments included: (a) Pre Teaching Self-Efficacy Questionnaire, (b) Follow-up Teaching Self-Efficacy Questionnaire, (c) Learner-Centered Teaching Knowledge Pretest, (d) Learner-Centered Teaching Knowledge Posttest, and (e) Retrospective Pre/Post Teaching Assessment Rubrics.

The teaching self-efficacy questionnaire (Appendix J) was developed by the course instructor, Neil Knobloch. The teaching self-efficacy items were adapted from "The Teachers' Sense of Efficacy Scale" developed by Tschannen-Moran and Hoy (2001). The scale was based upon the "Cyclical Nature of Teacher Efficacy" model by Tschannen-Moran, Hoy, and Hoy (1998, p. 228). The teaching self-efficacy questionnaire was reviewed by a panel of experts to establish face and content validity. The teaching self-efficacy questionnaire was administered to measure students' teaching self-efficacy regarding their beliefs about teaching and learning. The test consisted of 20 items with five-point scale responses: (a) Not at all/none, (b) Very little, (c) Some, (d) Quite a bit, and (e) Always/a lot. The remaining three questions inquired about student demographics. The follow-up teaching self-efficacy questionnaire (Appendix K) contained the pretest's original 20 questions, six demographic questions, and fifteen 21st Century Skills. The 21st Century Skills consisted of the following categories: (a) 5-critical thinking and problem solving, (b) 3-creativity and innovation, (c) 2-communication and collaboration, and (d) 5-life and career skills. The test response options followed the same five-point scale format as the teaching self-efficacy questions: (a) Not at all/none, (b) Very little, (c) Some, (d) Quite a bit, and (e) Always/a lot.

The Learner-Centered Teaching knowledge pre and post assessments were developed by the course instructor, Neil Knobloch. The LCT knowledge test was reviewed by a panel of experts to establish face and content validity. The Learner-Centered Teaching Knowledge Test was administered to measure the students' knowledge of course design and learner-centered teaching approaches. The Learner-Centered Teaching knowledge pretest consisted of 15 multiple-choice questions. The Learner-Centered Teaching knowledge posttest consisted of the identical 15 questions from the pretest plus an additional 15 questions. The arrangement of the post-test questions and answer choices were varied from the pretest to encourage the students to thoroughly read each question and the corresponding answers.

The retrospective pre/post teaching assessment rubrics were used to assess teaching performance and the extent the graduate students implement learner-centered teaching strategies. The LCT rubric was assembled by Neil Knobloch and Rebekah Nortrup, a Youth Development and Agricultural Education undergraduate research assistant. The LCT rubric was conceptualized using Knobloch's model of LCT and Nortrup's review of the literature. The teaching performance rubric consisted of items from the PRAXIS III (Danielson, 2007). At the completion of the teaching experience, the graduate teaching assistant (i.e., the researcher) facilitated an exit interview with each teaching team of graduate students. The interview included the graduate students' self-refection of their prior and post-teaching related behaviors. One rubric requested the graduate students to rate their Learner-Centered Teaching strategies regarding active learning (five sub-categories), inquiry learning (four sub-categories) and contextual learning (one sub-category). The rubric consisted of the following rating scale: (a) 0-1 low evidence, (b) 2-3 medium evidence, and (c) 4-5 high evidence. The Teaching Performance Rubric consisted of the following teaching domains and criteria: (a) planning (four sub-categories), (b) learning and instruction (five sub-categories), and (c) environment (four sub-categories). The rubric consisted of the following ratings: (a) 0-1 low evidence, (b) 2-3 medium evidence, and (c) 4-5 high evidence.

3.7.2 Qualitative Instruments

The qualitative sections of the study included reflection prompts for two essay assignments from the coursework completed by the graduate students and a follow-up interview questionnaire. The essay prompts reflected a variety of characteristics from the theoretical frameworks of teaching self-efficacy and expectancy value theory. The essay prompt for the volunteer non-formal teaching experience requested individual graduate students to reflect upon their experiences, describe the experience, and detail learning moments. The essay prompt for the formal K-12 teaching experience requested the graduate students to individually (a) reflect upon the experience, (b) develop a brief summary of their portion of the teaching experience, (c) detail how he or she used learner-centered teaching techniques to facilitate the learning, and (d) describe a reflection of his or her personal views of teaching in relation to his or her research career. The interview protocol was developed through reviewing the initial quantitative and qualitative data results from phase one of the sequential mixed methods design under the lens of the components of expectancy value and teaching self-efficacy. The semi-structured interview questions construction was guided through discussions and revisions with the researcher's committee members who were an experienced plant science graduate student instructor and a motivation and learner-centered teaching expert. The questions were field tested with graduate students with plant science backgrounds and previous teaching experience. The field tests were conducted as one-on-one videoed interviews to simulate the atmosphere and protocol of the research study. The field-tested questions were again reviewed by the researcher and the previously identified pair of academic experts prior to the final version of questions used and listed in Appendix L.

3.8 Threats to Validity and Measures to Ensure Reliability

The mixed-methods approach to this study imparted separate threats to external and internal validity. The limited number of participants, the purposive sample of participants, and the unique instructional conditions of the educational grant limited the generalizability of this study to the participants in this study. The conditions of internal validity were recognized and minimized according to the following protocol.

First, measurement validity was established by using assessment instrument items that were derived from empirically tested instruments for the established teaching self-efficacy construct. The Learner-Centered Teaching knowledge assessment and the teaching self-efficacy questionnaire were evaluated for face and content validity by an expert panel. Reliability was established by utilizing instrument elements which had previous consistent and predictable results from well-established teaching self-efficacy studies (Tschannen-Moran et al., 1998). The LCT knowledge assessment and retrospective LCT pre/post teaching rubric were developed by the course instructor and based upon online professional development modules (Knobloch, 2008). The Teaching Performance Rubric side of the retrospective LCT pre/post teaching rubric was developed from established PRAXIS III questions (Danielson, 2007). Because of the small sample size, initial results from a convenient sample *(N = 33)* were used to establish reliability of the teaching self-efficacy questionnaire and the LCT knowledge pretest and posttest. The reliability of the self-efficacy questionnaire was established by calculating the post-hoc Cronbach's alpha coefficient for 20 items ($\alpha = 0.90$). The reliability of the knowledge pretest were established by calculating the post-hoc Cronbach's alpha coefficient for 15 items ($\alpha = 0.71$). The reliability of the knowledge posttest was calculating the post-hoc Cronbach's alpha coefficient for 30 items ($\alpha = 0.55$). The following question was removed from the knowledge posttest to increase the post-hoc Cronbach's alpha ($\alpha = 0.62$): The following are all strategies for assessment in a learning environment. Which of the following would be most appropriate to use as a formative assessment? Deleting items has been suggested by researchers to improve reliability ratings of instruments (Radhakrishna, 2007). Field (2009) cautions the interpretation of Cronbach's alpha when measuring constructs with diversity such as knowledge tests, low item numbers, and low number of respondents. The Cronbach's alpha coefficients (> .60) for the knowledge tests provided results consistent and adequate for cognitive assessments within this designated field of study (Suhr & Shay, 2009).

Second, qualitative researchers advocate for authentic and trustworthy reflections of the participants throughout their studies (Norman Kent Denzin & Lincoln, 2005). Qualitative research requires the researcher to be transparent and honest about personal experiences and biases that may be perceived as supportive or conflicting with the study's findings (Patton, 2002). As such, the researcher implemented protocols to define objectivity, structure auditability and document authenticity as recommended by Miles et al. (2014). Objectivity was established by detailing the protocol for in-depth methods and procedures, the role of the researcher throughout the study, and the adherence to a conceptual and theoretical framework (Miles et al., 2014). Auditability was established by examining parallelism across data sources, adhering to a clearly specified paradigm, and consulting the course instructor for verification of conflicting accounts (Miles et al., 2014). Authenticity was established by systematically relating content, by converging conclusions from multiple data sources, and by identifying and describing negative findings (Norman K Denzin & Lincoln, 2011; Miles et al., 2014). The trustworthiness of this study was guided by protocol in credibility, transferability, dependability, and confirmability (Norman K Denzin & Lincoln, 2011). Triangulation of data from multiple sources was utilized to establish credibility (Patton, 2002). When possible, *in vivo* statements were used from the video interviews to support transferability of this study to similar graduate student experiences. Weekly meetings with the researcher's advisor and intermittent meetings with the graduate committee members provided an external audit of findings and attributed interpretations to the study's findings and identified the researcher's bias, thus supporting dependability of the study. Although no formal member checks were conducted, informal member checks were conducted throughout the video interviews to gain a full understanding of the participants' responses and support the trustworthiness of the qualitative data analysis (Miles et al., 2014). Lastly, an audit trail and consistent reflexivity by the researcher throughout the study was established to provide confirmability with the research protocol (Patton, 2002).

3.9 The Role of the Researcher: Biases

The researcher worked for 12 years as a K-12 Family and Consumer Sciences teacher. She previously participated in the Ag in the Classroom program sponsored by the Pennsylvania Farm Bureau. Ag in the Classroom was a week long course taught at The Pennsylvania State University, State College, Pennsylvania to assist teachers in developing lessons infused with agricultural content. The researcher was raised on a farm and participated in farm-related youth activities, such as 4-H. The researcher also served as a Cambria County agricultural advocate to local and state media. The researcher conducts business as part owner and operator of a farm and an agricultural based business. The researcher was a spokesman for the Pennsylvania Cattlemen's Association and the Pennsylvania Beef Council during her tenure as Pennsylvania Beef Ambassador and Pennsylvania Cattlemen's Queen. Thus, the researcher has a strong passion for developing agricultural literacy. The researcher monitored her biases by debriefings with her research advisor and graduate committee members. Furthermore, the researcher attempted to reduce language bias by presenting the study utilizing terminology consistent with the study's conceptual and theoretical framework. Although the researcher completed multiple basic and advanced coursework with qualitative instruction, the researcher has novice qualitative coding skills.

3.10 Data Collection

Data collection for the mixed methods multi-phase study was completed in several stages (see Figure 3.1). Quantitative and qualitative data from graduate student participants' class assignments were examined for this research study after all classes were complete and grades were posted through the university bursar office. After the final group of students completed the last class, a period of 16 months passed before a letter was sent to selected study participants electronically as an invitation to complete a teaching self-efficacy questionnaire and participate in a follow-up interview. All data collected that may have contained personally identifiable information were removed from the data files and replaced by pseudonyms. Qualitative data identifications were replaced with pseudonyms.

3.10.1 Quantitative Data

The quantitative data collected for this study from four class assignments included: (a) pre teaching self-efficacy questionnaire, (b) learner-centered teaching knowledge pretest, (c) learner-centered teaching knowledge posttest, and (d) retrospective pre/post teaching assessment rubrics. The data from the follow-up post-teaching self-efficacy questionnaire was obtained prior to the participant completing the videoed interview.

3.10.2 Qualitative Data

Qualitative data was collected for this study in two formats. The first format was document artifacts. Document artifacts were derived from two class assignments completed by participants. The students completed the assignments prior to the start of this research study. The qualitative document data sources included: (a) volunteer non-formal teaching experience summary, and (b) formal teaching experience summary. The second format was a semi-structured video interview with each participant in this study. The semi-structured interviews were formatted to be conversational versus interrogatory (Wengraf, 2001). Interview questions were somewhat adapted from the original script with the participants and included the use of probing questions to provide clarity to participants' responses. A detailed questionnaire with prompts has been provided in Appendix F. The participants received the opportunity to request a copy of their individual video from the researcher as a benefit for their professional development. Audio clips from the videos were transcribed by a transcription service into typed transcripts. The researcher reviewed and compared the transcripts with the video clips to verify the accuracy of the transcribed conversations. Corrections to the transcriptions were minimal but necessary due to the specific terminology described throughout the interviews and the fluctuations in vocal tone.

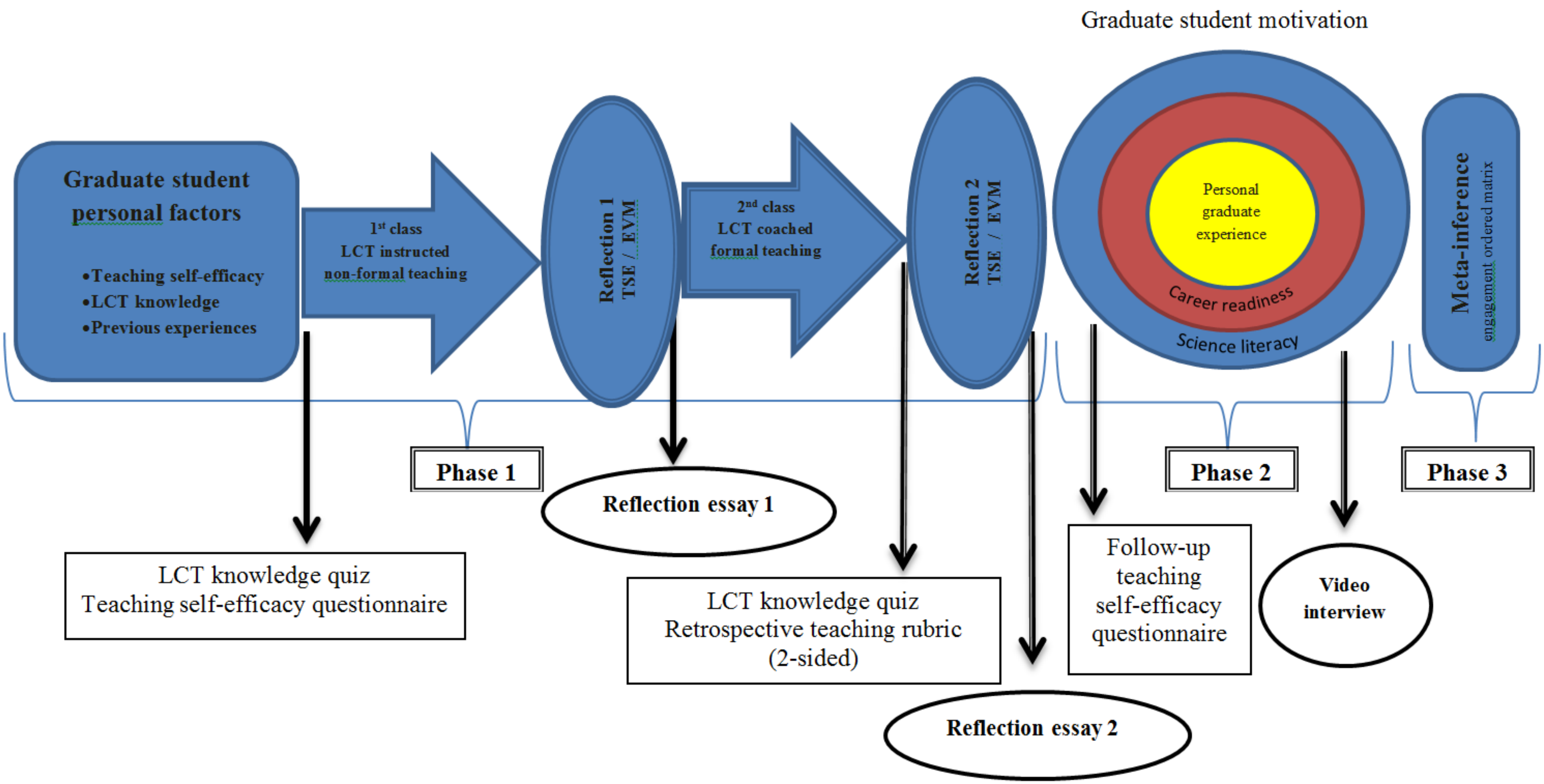

Figure 3.1 Conceptual Diagram with Data Collection Points
Note: Qualitative items noted by circles, Quantitative items noted by rectangles

3.11 Data Analysis

Data analysis was conducted in three phases. According to the sequential mixed-methods design the phases and sub-stages were completed sequentially. Data were initially summarized according to quantitative and qualitative methods within each sub-stage and collectively synthesized in a meta-analysis. Data sources and the method of data analysis were organized by research phase, described according to quantitative and qualitative methods, and presented in Table 3.3.

Table 3.3 Data Sources and Method of Analysis

Phase/ Methodology	Data Source	Analysis Method/ Coding strategy
Phase one		
Quantitative	Pre teaching self-efficacy questionnaire	Descriptive statistics
	Learner-centered teaching knowledge pretest	Descriptive statistics
	Learner-centered teaching knowledge posttest	Descriptive statistics
	Retrospective pre/post teaching assessment	Descriptive statistics
Qualitative		
	Volunteer non-formal teaching experience summary	Descriptive/in vivo/ provisional coding
	Formal teaching experience summary	Descriptive/in vivo/ provisional coding
Phase two		
Quantitative	Follow-up teaching self-efficacy questionnaire	Descriptive statistics
Qualitative	Semi-structured interview	Holistic/in vivo/ provisional coding
Phase three		
Meta-synthesis	Phase one and two summarized data	Engagement ordered Matrix

3.11.1 Phase One Analysis

In the first phase, a quantitative descriptive analysis was completed to describe and compare central tendencies of the participants' responses. Responses from the (a) learner-centered teaching knowledge pretests, (b) learner-centered teaching knowledge posttests, (c) teaching self-efficacy pre-questionnaires, and (d) retrospective pre/post teaching assessment rubrics were entered and analyzed using the Statistical Package for Social Sciences (SPSS) software. Means, standard deviations, frequencies, and percentages were calculated and reported for the LCT knowledge pre/post, teaching self-efficacy, and retrospective pre/post teaching assessments. The level of measurement of subscales used to measure the dependent and independent variables were displayed in Table 3.4. Practical significance was determined by using effect sizes. Effect sizes were calculated using Cohen's *d* and evaluated according to the descriptors for the Cohen's *d* scale.

In the qualitative analysis, first coding was completed on the non-formal experience reflection essay and the K-12 teaching reflection essay document artifacts. Descriptive coding, and when possible *in vivo* coding, were used to summarize content. The second coding, provisional coding, was completed on the non-formal teaching reflection essay document artifacts using teaching-self efficacy terms and expectancy value theory terms. Provisional coding was the process that guided the use of multiple expectancy value theory motivation lens to be used to re-examine the documents, hence the use of pre-determined motivational terms to function as the analytical lens. Provisional coding "corroborates or builds upon previous research or investigations" (Saldaña, 2013, p. 144). The two methods of analysis were selected to gain a deeper understanding of the graduate students' motivation in addition to complying with the demand for "meticulous attention to language and deep reflection" as required by qualitative inquiry (Saldaña, 2013, p. 10).

3.11.2 Phase Two Analysis

In the second phase, a quantitative descriptive analysis was completed to describe and compare central tendencies of the participants' responses. Responses from the follow-up Teaching Self-Efficacy questionnaires were entered and analyzed using the SPSS software. Means, standard deviations, frequencies and percentages were calculated and reported for teaching self-efficacy and 21st Century Skill responses. The level of measurement of subscales used to measure the dependent and independent variables is displayed in Table 3.4. Practical significance was determined by using effect sizes. Effect sizes were calculated using Cohen's *d* and evaluated according to the descriptors for the Cohen's *d* scale.

In the qualitative analysis, first coding was completed on interview transcripts. Holistic coding, and when possible *in vivo* coding, were used to summarize content. The second coding, provisional coding, was completed on interview transcripts using teaching self-efficacy terms and expectancy value theory motivation terms (see Table 3.5). Provisional coding was the process that guided the use of teaching self-efficacy and multiple expectancy value theory motivation lenses to be used to re-examine the interviews. The researcher referenced the video interviews throughout the analysis process to verify the contextualized statements.

Table 3.4 Level of Measurement, Central Tendency and Variance According to Variable and Data Source

Variable	Data source	Level of Measurement	Central Tendency	Variance
Beliefs about Teaching and Learning (self-efficacy)	Teaching Self-efficacy questionnaire	Item: Ordinal Scale: Interval	Mean	Standard Deviation
Learning design experience	Teaching Self-efficacy questionnaire	Item: Ordinal Scale: Interval	Mean	Standard Deviation
Learner-Centered Teaching Knowledge	LCT Knowledge Pre & post tests	Ratio	Mean (Percentage Correct)	Standard Deviation
Attainment Value	Teaching reflections & Interview	Nominal	Frequency	N/A
Intrinsic value	Teaching reflections & Interview	Nominal	Frequency	N/A
Utility value	Teaching reflections & Interview	Nominal	Frequency	N/A
Cost belief	Teaching reflections & Interview	Nominal	Frequency	N/A
LCT Teaching Perception	Retrospective Teaching Assessment Rubrics	Item: Ordinal Scale: Interval	Mean	Standard Deviation
Career Goal	Teaching reflections & Interview	Nominal	Frequency	N/A

Note. In the event that a large enough number of participants respond, a Cronbach's alpha post-hoc reliability may be run to establish the reliability of the questionnaire and test questions within the data set.

Table 3.5 Provisional Coding Scheme: Motivational Points of Interest

Motivation construct	Description [Identifying features derived from: Schunk et al. (2008, pp. 50-63)]	Description [Identifying features derived from : Tschannen-Moran and Hoy (2001, p. 800)]
Teaching self-efficacy		"Efficacy to engage with students" "Efficacy to make expectations clear" "Efficacy for classroom management"
Expectancy	"Ability to do the task" "Future success with this task"	
Attainment value/ importance	"Doing well on a task" "Emphasis on success with task" "How important was the task"	
Intrinsic interest/ intrinsic value	"Enjoyment value" "Enjoyment when doing the task" "Subjective interest"- (Personal interest)	
Utility value	"Usefulness of task" "Relation to future goals" "Relation to career goals"	
Cost belief	"Perceived negative aspect of doing task" "Worth doing whole giving up another choice" "Perceived amount of effort" "Anticipated emotional state"	

Lastly, an engagement-ordered matrix was developed to compile the findings of all synthesized data for a meta-inference. This matrix organized data for each participant into a row and corresponded to specific data points in the columns. The construction and analysis of this matrix took place in four parts. First, a response for each data point was designated as a column. Second, representative holistic and *in vivo* coding from the qualitative phase was selected placed into corresponding columns along with the quantitative data. Third, two tactics were used to analyze the matrix: (a) Counting and making comparisons and (b) noting relations between variables (Miles et al., 2014). Fourth, a summary narrative was developed to distinguish the relationships between expectancy value motivations, graduate students' demographics, LCT knowledge, and teaching self-efficacy. Thus, the matrix display permitted systematic comparisons across participants' demographics to examine similarities and differences within each motivational point of interest.

CHAPTER 4. RESULTS

4.1 Purpose of the Study

Graduate students have been trained to participate in outreach experiences to disseminate their research to a K-12 audience yet little is known about plant science graduate students' science literacy outreach teaching beliefs and values. Particularly, it is important to describe the professional development of graduate students in regards to specific training. Training was offered as two college credit courses facilitating learner-centered teaching strategies to engage K-12 students with agricultural research content. The purpose of this mixed methods study was to describe plant science graduate students' outreach teaching beliefs and values after receiving outreach training. The training consisted of learning and practicing learner-centered teaching strategies with the focus of disseminating research as science literacy to a K-12 audience.

4.2 Research Questions for the Study

1. What knowledge of LCT content did plant science graduate students' possess before and after the two-credit experience?
2. What beliefs and values do plant science graduate students express during and after participation in an integrated two-credit college pedagogical learning course and K-12 outreach experience as expressed through the following sub-questions?

    (a) What were graduate students' teaching self-efficacy scores prior to the experience?

(b) What were graduate students' self-reflected post-teaching and retrospective pretest ratings for demonstrating LCT concepts, planning, learning, instruction, and environmental teaching domains?

(c) What beliefs and values did students reflect upon and describe in their reflection essays?

3. Upon completion of the integrated graduate student training experience, what beliefs and values did graduate students describe from the K-12 experience regarding personal graduate experience, career readiness, and science literacy?

4.3 Results for the study

The results of the study were organized and presented for each research question. Tables were developed to organize and visually represent the data. Finally, quantitative and qualitative data were analyzed separately and then triangulated within an engagement ordered matrix.

4.3.1 Results for Research Question One:

For the first research question, plant science graduate students' knowledge of learner-centered teaching content was assessed before and after the two-credit experience. Graduate students completed two assessments. The second assessment contained an additional 15 unique questions to examine LCT knowledge.

Graduate students' scores on the knowledge posttests were higher at the conclusion of the courses in comparison to scores on the knowledge pretest (Table 4.1). Students correctly answered 67% (SD = 11.27) of the knowledge questions on the pretest and 76% (SD = 11.08) on the posttest. When comparing identical questions from the pretest to the posttest, there was an increase of 9 percent with a large effect size (Cohen's d = .81). A large effect size demonstrated that students' knowledge of LCT would be higher upon course completion and thus evident to casual observers of the program.

However, these differences in knowledge are descriptive and cannot be interpreted as a cause-effect relationship because of the non-experimental design of the study.

Table 4.1 Pretest and Posttest Summary

(*n* = 17)	*M (SD)* % Correct	*Cohen's d*
LCT knowledge pretest (15 items)	67.45 (11.28)	.81
LCT knowledge posttest (15 items)	76.47 (11.08)	
LCT knowledge posttest (30 items)	69.41 (11.50)	
LCT knowledge unique posttest (15 items)	62.35 (17.47)	.35

Note. Number denoted in parenthesis is total number of questions. Knowledge posttest questions (15) were identical questions in comparison to pretest.

The participants' answers were summarized within the LCT pretest (Table 4.2), LCT posttest (Table 4.3), and unique LCT posttest (Table 4.4). The questions on the posttest identical to the pretest were rearranged by question and answer to match the pretest for analysis. For further *post hoc* analysis, the questions were aligned according to two domains of Danielson's (2007) *Enhancing professional practice: A framework for teaching*: (a) planning and preparation, and (b) instruction. The questions reflected three components within the planning and preparation domain and four components within the instruction domain. There were seven questions which reflected the following three components of the planning and preparation domain: (a) setting instructional outcomes, (b) designing coherent instruction, and (c) designing student assessments. There were eight questions which reflected the following four components of the instruction domain: (a) using questioning and discussion techniques, (b) engaging students in learning, (c) using assessment in instruction, and (d) demonstrating flexibility and responsiveness. The correct response for individual questions was denoted by the answer with the boldfaced type print. Notably, three questions (What is the purpose of assessing students? How should learning objectives be written? What is not an example of active learning?) received correct responses by all graduate students on the pretest (Table 4.2). The following single question (The following are all strategies for assessment in a learning environment. Which of the following would be most appropriate to use as a formative assessment?) received zero correct responses by the graduate students on the pretest (Table 4.2). In contrast, a total of five identical questions from the pretest were correctly answered by all graduate students on the posttest (Table 4.3). A single question (How should learning objectives be written?) received the correct responses on the posttest was also answered correctly by all graduate students on the pretest.

In examining a summary of correct responses on the knowledge tests, more students correctly answered 9 of the fifteen identical questions on the posttest than the pretest (Tables 4.5 and 4.6). Graduate students reported the most change from the posttest compared to the pretest on the following items: (a) correctly written learning objective (+35.3%), (b) strategies used for formative assessments (+35.3%), (c) identifying inquiry learning (+23.6%), and (d) components of an assessment task (+23.5%). Graduate students reported smaller increases in knowledge on the following items: (a) LCT methodologies (+11.8%), (b) should professors engage students (+11.8%), (c) characteristics to consider when designing a course (+11.8%), (d) level of cognition (+5.9%), and (e) professor’s role in LCT classroom (+5.9%). Conversely, the results also identified graduate students were not as likely to correctly identify the steps to design a course using backward design and LCT strategies (-17.7%).

The additional unique questions examined on the extended posttest displayed some acquisition of knowledge 62% (*SD* = 17.47). Although the practical difference was a small effect size (*d* = .35), the students performed slightly more than one-third of a letter grade higher on the extended knowledge posttest. Questions reflecting the acquisition of major topics addressed within class activities were noted by the following items: (a) active learning strategies (100.0%), (b) active learning methods (88.2%), (c) classroom active learning activities (88.2%), (d) what is a concept (88.2%), (e) seminar games (76.5%), (f) define backwards design (70.6%), and (g) examples of active learning (70.6%). The prominent focus on active learning in the course may have been further evident by graduate students scoring low on the following questions focused on inquiry learning: define inquiry learning (17.6%) and an AFRI student developing inquiry (23.5%).

Table 4.2 LCT Knowledge Pretest Responses

Questions (15 items) (*N* = 17)	*f* A	*f* B	*f* C	*f* D	*f* E
Planning and Preparation					
How should learning objectives be written*	0	0	**3 (17.6%)**	0	**14 (82.4%)**
Which learning objective is written correctly	3 (17.6%)	**6 (35.3%)**	3 (17.6%)	1 (5.9%)	4 (23.5%)
What characteristics should be considered while designing a class activity	0	**15 (88.2%)**	2 (11.8%)	0	0
Which steps should be taken when designing a course	0	2 (11.8%)	**13 (76.5%)**	2 (11.8%)	0
How does the course design influence student learning	0	**16 (94.1%)**	1 (5.9%)	0	0
What are the components of an assessment task	14 (82%)	1 (5.9%)	**1 (5.9%)**	0	1 (5.9%)
What is the purpose of assessing students	0	**17 (100%)**	0	0	0
Instruction					
What should professors do to engage students in a course	**15 (88.2%)**	0	1 (5.9%)	0	1 (5.9%)
What do you believe is a professor's role in a learner-centered classroom	0	1 (5.9%)	0	**16 (94.1%)**	0
What is not an example of active learning	0	**17 (100%)**	0	0	0
What is not an example of inquiry learning	1 (5.9%)	0	6 (35.3%)	**9 (52.9%)**	1 (5.9%)
What is not an example of contextual learning	3 (17.6%)	2 (11.8%)	**5 (29.4%)**	1 (5.9%)	6 (35.3%)
Which statement is wrong about LCT methodologies	0	0	**15 (88.2%)**	0	2 (11.8%)
What level of cognition is the following question addressing	0	2 (11.8%)	**11 (64.7%)**	1 (5.9%)	3 (17.6%)
The following are all strategies for assessment in a learning environment. Which of the following would be most appropriate to use as a formative assessment	4 (23.5%)	2 (11.8%)	**0 (0.0%)**	4 (23.5%)	7 (41.2%)

Note. The correct answers are marked in boldfaced type.

*both response choices were designated as correct

Table 4.3 LCT Knowledge Posttest Responses

Questions (15 items) (*N* = 17)	*f* A	*f* B	*f* C	*f* D	*f* E
Planning and Preparation					
How should learning objectives be written*	0	0	**4 (23.5%)**	0	**13 (76.5%)**
Which learning objective is written correctly	2 (11.8%)	**12 (70.6%)**	2 (11.8%)	0	1 (5.9%)
What characteristics should be considered while designing a class activity	0	**17 (100%)**	0	0	0
Which steps should be taken when designing a course	0	3 (17.6%)	**10 (58.8%)**	0	4 (23.5%)
How does the course design influence student learning	0	**16 (94.1%)**	1 (5.9%)	0	0
What are the components of an assessment task	5 (29.4%)	3 (17.6%)	**5 (29.4%)**	0	4 (23.5%)
What is the purpose of assessing students	0	**16 (94.1%)**	1 (5.9%)	0	0
Instruction					
What should professors do to engage students in a course	**17 (100%)**	0	0	0	0
What do you believe is a professor's role in a learner-centered classroom	0	0	0	**17 (100%)**	0
What is not an example of active learning	1 (5.9%)	**16 (94.1%)**	0	0	0
What is not an example of inquiry learning	0	1 (5.9%)	2 (11.8%)	**13 (76.5%)**	1 (5.9%)
What is not an example of contextual learning	1 (5.9%)	1 (5.9%)	**4 (23.5%)**	2 (11.8%)	9 (52.9%)
Which statement is wrong about LCT methodologies	0	0	**17 (100%)**	0	0
What level of cognition is the following question addressing	0	1 (5.9%)	**12 (70.6%)**	1 (5.9%)	3 (17.6%)
The following are all strategies for assessment in a learning environment. Which of the following would be most appropriate to use as a formative assessment**	2 (11.8%)	9 (52.9%)	**6 (35.3%)**	2 (11.8%)	4 (23.5%)

Note. Answers were transcribed to match pretest order.

*both response choices correct

** missing one response.

Table 4.4 LCT Knowledge Tests' Unique 15 Item Correct Responses (Extended Posttest Items)

Questions (15 items) (*N* = 17)	*f* A	*f* B	*f* C	*f* D	*f* E
Planning and Preparation					
As an educator, one should consider the nature of the learning task when designing the learning activities. Which statement does NOT support why this is important?	2 (11.8%)	1 (5.9%)	2 (11.8%)	**11 (64.7%)**	1 (5.9%)
Learning objectives are essential to helping the educator focus an educational plan. Which of the following statements is NOT true about learning objectives?	2 (11.8%)	6 (35.3%)	2 (11.8%)	**7 (41.2%)**	0
A concept is?	1 (5.9%)	**15 (88.2%)**	1 (5.9%)	0	0
Backward Design is a process used to develop educational plans. What is the correct sequence of tasks for an instructional designer who uses backward design?	1 (5.9%)	**12 (70.6%)**	2 (11.8%)	2 (11.8%)	0
Once you have identified a topic you wish you teach, what is the next step in developing a unit or program plan?	3 (17.6%)	3 (17.6%)	0	**11 (64.7%)**	0
Evaluation can be formative or summative. Which statement is most accurate?	0	0	6 (35.3%)	**11 (64.7%)**	0
Instruction					
Which of the following statements is true about LCT?	1 (5.9%)	**5 (29.4%)**	0	11 (64.7%)	0
Active learning is?	2 (11.8%)	**8 (47.1%)**	3 (17.6%)	4 (23.5%)	0
In-class discussions, peer teaching, and cooperative learning are examples of which strategy of active learning?	1 (5.9%)	3 (17.6%)	**12 (70.6%)**	1 (5.9%)	0
Inquiry learning can be inductive or deductive. Which of the following statements is true?	4 (23.5%)	4 (23.5%)	**3 (17.6%)**	6 (35.3%)	0
The games that were played in seminar were an example of what?	**13 (76.5%)**	3 (17.6%)	1(5.9%)	0	0
The following methods (chunking, songs, analogies, metaphors, real-life examples, being enthusiastic) represent which strategy of active learning?	0	**15 (88.2%)**	2 (11.8%)	0	0
The following methods (videos, demonstrations, real objectives, animations, concept maps) represent which strategy of active learning?	**17 (100%)**	0	0	0	0
The one-minute paper, stump the professor, thumbs up/down, clickers, and review games represent which strategy of active learning?	1 (5.9%)	0	1 (5.9%)	**15 (88.2%)**	0
An AFRI student would like to develop skills in school students related to science in which of the following ways?	0	9 (52.9%)	**4 (23.5%)**	4 (23.5)	0

In comparing means and standard deviations of the criteria groupings for correct responses, there were differences among the pretest and posttest scores for the domain group *planning and preparation* (Table 4.5) and the domain group *instruction* (Table 4.6). An average of 71% (*SD* = 36.64) of individuals selected the correct responses to the pretest questions in the *planning and preparation* domain. In comparison an average of 78 % (*SD* = 26.68) of individuals selected the correct responses to the posttest questions in the *instruction* domain. On the pretest and posttest, 100 % of graduate students selected the correct response for the following question: How should learning objectives be written? In contrast, a low number of graduate students (5.9% pretest and 29.4% posttest) were able to select the correct response for the following question: What are the components of an assessment task. The greatest percentage difference between pretest and posttest questions in the *planning and preparation* domain was 35% for the question: Which learning objective was written correctly? The greatest percentage difference between pretest and posttest questions in the *instruction* domain was 35% for the question: The following are all strategies for assessment in a learning environment, which of the following would be most appropriate to use as a formative assessment?

The unique questions on the extended posttest provided some additional insight into the graduate students' knowledge of learner-centered teaching content within the *planning and preparation* and *instruction* domains. An average of 66% (*SD* = 15.06) of individuals selected the correct responses to the unique questions on the extended posttest in the *planning and preparation* domain. Likewise, an average of 60% (*SD* = 31.24) of individuals selected the correct responses to the unique questions on the extended posttest in the *instruction* domain. The questions featuring active learning concepts were answered with the most correct responses by graduate students. A small percentage of graduate students (17.6%) were able to select the correct response for the following question: Inquiry leaning can be inductive or deductive: which of the following statements is true?

Table 4.5 LCT Knowledge Tests' Performance (Domain 1)

(*N* = 17)	Pretest %	Posttest %	Difference
Planning and Preparation			
How should learning objectives be written	100.0	100.0	0.0
Which learning objective is written correctly	35.3	70.6	35.3
What characteristics should be considered while designing a class activity	88.2	100.0	11.8
Which steps should be taken when designing a course	76.5	58.8	-17.7
How does the course design influence student learning	94.1	94.1	0.0
What are the components of an assessment task	5.9	29.4	23.5
What is the purpose of assessing students	100.0	94.1	-5.9
(M / SD)	*(71.43 / 36.64)*	(78.15 / 26.68)	
As an educator one should consider the nature of the learning task when designing the learning activities. Which statement does not support why this is important		64.7	-
Learning objectives are essential to helping the educator focus an educational plan. Which of the following statements is not true about learning objectives		41.2	-
A concept is		88.2	-
Backward Design is a process used to develop educational plans. What is the correct sequence of tasks for an instructional designer who uses backward design		70.6	-
Once you have identified a topic you wish to teach, what is the next step in developing a unit or program plan		64.7	-
Evaluation can be formative or summative. Which statement is most accurate		64.7	-
(M/ SD)		*(65.68 / 15.06)*	

Table 4.6 LCT Knowledge Tests' Performances (Domain 2)

(*N* = 17)	Pretest %	Posttest %	% Difference
Instruction			
What should professors do to engage students in a course	88.2	100.0	11.8
What do you believe is a professor's role in a learner-centered classroom	94.1	100.0	5.9
What is not an example of active learning	100.0	94.1	-5.9
What is not an example of inquiry learning	52.9	76.5	23.6
What is not an example of contextual learning	29.4	23.5	-5.9
Which statement is wrong about LCT methodologies	88.2	100.0	11.8
What level of cognition is the following question addressing	64.7	70.6	5.9
The following are all strategies for assessment in a learning environment. Which of the following would be most appropriate to use as a formative assessment	0.0	35.3	35.3
(M/ SD)	*(64.69 / 35.43)*	*(75.00 / 30.45)*	
Which of the following statements is true about LCT		29.4	-
Active learning is		47.1	-
In-class discussions, peer teaching, and cooperative learning are examples of which strategy of active learning?		70.6	-
Inquiry leaning can be inductive or deductive. Which of the following statements is true		17.6	
The games that were played in seminar were an example of what		76.5	-
The following methods (chunking, songs, analogies, metaphors, real-life examples, being enthusiastic) represent which strategy of active learning?		88.2	-
The following methods (videos, demonstrations, real objectives, animations, concept maps) represent which strategy of active learning?		100.0	-
The one-minute paper, stump the professor, thumbs up/down, clickers, and review games represent which strategy of active learning		88.2	-
An AFRI student would like to develop skills in school students related to science in which of the following ways		23.5	-
(M/ SD)		*(60.12 / 31.24)*	

4.3.2 Results for Research Question Two:

For the second research question, plant science graduate students' beliefs and values were examined prior to, throughout and following their participation in an integrated two-credit college pedagogical learning course and K-12 outreach experience. The beliefs and values were examined through a series of three sub-questions.

4.3.2.1 Results for Research Question Two A:

The first of the beliefs and values sub-questions within question two examined the graduate students' initial teaching self-efficacy scores through a quantitative method of reporting. Graduate students completed a self-efficacy questionnaire at the beginning of the first course in the integrated two-credit college pedagogical learning course.

Teaching self-efficacy scores at the beginning of the experience depicted graduate students as overall feeling "somewhat" self-efficacious with teaching (Table 4.7) with an overall mean of 3.58 (*SD* = .38). Graduate students rated themselves as "quite a bit" teaching self-efficacious on half of the items listed. Markedly, graduate students noted that making their students believe they are able to learn and apply the content (64.7%) was listed high for feeling "quite a bit." While the extent graduate students felt they could design learning activities to help students to learn the content was also high (64.7%) with the "some" rating. Graduate students varied in their ratings for perceiving their ability to write clear learning objectives using Bloom's taxonomy mostly at the "very little" rating (41.2%). Highest perceptions in the "always/a lot" rating revolved around the concepts of (a) engaging students to work as a team (23.5%), (b) creating an interactive learning environment (23.5%), and (c) making expectations clear to students (23.5%).

Table 4.7 Pretest Teaching Self-Efficacy

Teaching Self-Efficacy Items *N* = 17	None	Very Little	Some	Quite a bit	Always/ a lot
How much can you influence student learning?	0	0	6 (35.3%)	8 (47.1%)	3 (17.6%)
How much can you challenge student to think more critically?	0	1 (5.9%)	5 (29.4%)	10 (58.8%)	1 (5.9%)
How much can you motivate students to participate in class activities?	0	0	7 (41.2%)	9 (52.9%)	1 (5.9%)
How much can you engage students to work as a team?	0	1 (5.9%)	6 (35.3%)	6 (35.3%)	4 (23.5%)
To what extent can you create an interactive learning environment?	0	0	8 (47.1%)	5 29.4%)	4 23.5%)
To what extent can you bring real-life experiences to the classroom?	0	0	6 (35.3%)	8 (47.1%)	3 (17.6%)
To what extent are you prepared to teach the courses you are assigned to teach?	0	0	7 (41.2%)	7 (41.2%)	3 (17.6%)
To what extent can you clearly communicate the content so students will understand?	0	0	6 (35.3%)	9 (52.9%)	2 (11.8%)
To what extent can you make students believe they are able to learn and apply the content?	0	1 (5.9%)	3 (17.6%)	11 (64.7%)	2 (11.8%)
To what extent can you adjust your teaching to accommodate different learning styles of students?	0	1 (5.9%)	10 (58.8%)	5 (29.4%)	1 (5.9%)
How effectively can you facilitate an engaging class discussion?	0	3 (17.6%)	8 (47.1%)	4 (23.5%)	2 (11.8%)
To what extent can you incorporate different teaching methods in your lessons?	0	0	10 (58.8%)	5 (29.4%)	2 (11.8%)
To what extent can you make your expectation clear to students?	0	0	3 (17.6%)	10 (58.8%)	4 (23.5%)
To what extent can you write clear learning objectives using Bloom's taxonomy?	1 (5.9%)	7 (41.2%)	5 (29.4%)	2 (11.8%)	2 (11.8%)
To what extent can you design learning activities to help students to learn the content?	0	0	11 (64.7%)	4 (23.5%)	2 (11.8%)
How effective can you provide alternative explanations to clarify the main idea?	0	0	10 (58.8%)	5 (29.4%)	2 (11.8%)
To what extent can you apply different assessment methods beyond a knowledge test?	0	4 (23.5%)	10 (58.8%)	2 (11.8%)	1 (5.9%)

Table 4.7 Continued

To what extent can you provide students with specific feedback about their performance to help them learn?	0	0	5 (29.4%)	10 (58.8%)	2 (11.8%)
To what extent do you think your students would score well in the exams due to your teaching?	0	0	9 (52.9%)	8 (47.1%)	0
To what extent would your students be able to apply the concepts learned in class to real-life situations?	0	0	9 (52.9%)	8 (47.1%)	0
Grand Mean = 3.58 SD = .38					

Note. 1= None, 2 = Very little, 3 = Some, 4 = Quite a bit, 5 = Always/A Lot

4.3.2.2 Results for Research Question Two B:

The second of the beliefs and values sub-questions examined the graduate students' self-reflected post-teaching and retrospective pre-teaching ratings for demonstrating comprehensive teaching concepts (planning, learning and instruction, and environmental teaching domains) and LCT concepts (active, inquiry, and contextual domains). The two post-teaching rubrics were completed by 17 individuals after they taught a K-12 audience within a school setting. Each of the graduate students self-evaluated their retrospective pre-teaching and post-teaching skills for 13 criteria on the comprehensive teaching rubric (Table 4.8) and 10 criteria on the LCT rubric (Table 4.9). The results are summarized according to domains and criteria.

The analysis for the results of the comprehensive teaching rubric presented the following effect size results for the criteria within the *planning domain*: learning goals (d = 1.34), methods, activities, materials, and resources (d = 2.11), content connections (d = 1.33), and evaluation strategies (d = 1.83). The analysis for the results of the comprehensive teaching rubric presented the following effect size results for the criteria within the *learning and instruction domain*: goals and procedures (d = 1.23), comprehensible content (d = 1.67), extend thinking (d = 1.53), monitor understanding (d = 1.28), and use of time (d = 1.18). In the *planning* and *learning and instruction* domains, the effect size results were all rated as having a large effect size for Cohen's *d*. The analysis for the results of the comprehensive teaching rubric presented the following effect size results for the criteria within the *environment domain*: physical environment (*d* = 0.69), classroom behavior (*d* = 1.08), rapport (*d* = 1.24), and reflection of goals (*d* = 1.96). The effect size for the physical environment criteria was rated as having a medium effect size for Cohen's *d*, while the other criteria in the environment domain were rated as having large effect sizes.

Table 4.8 Domains and Criteria Summaries for the Comprehensive Teaching Rubric

(*N* = 17)	Domain/Criteria	Pre-Teaching Rating *M (SD)*	Post-Teaching Rating *M (SD)*	Difference (Cohen's *d*)
Planning	Learning Goals	2.58 (1.28)	4.06 (.90)	1.34
	Methods, Activities, Materials, Resources	2.53 (.80)	4.12 (.70)	2.11
	Content Connections	2.24 (1.15)	3.71 (1.05)	1.33
	Evaluation Strategies	2.35 (1.00)	4.00 (.79)	1.83
Planning M (*SD*)		2.43 (.82)	3.97 (.62)	2.12
Learning and Instruction	Goals & Procedures	2.53 (1.12)	3.71 (.77)	1.23
	Comprehensible Content	2.65 (.93)	4.06 (.75)	1.67
	Extend Thinking	2.18 (.81)	3.71 (1.16)	1.53
	Monitor Understanding	2.18 (1.13)	3.65 (1.17)	1.28
	Use of Time	2.53 (1.23)	3.88 (1.05)	1.18
Learning and Instruction M (SD)		2.41 (.91)	3.80 (.74)	1.68
Environment	Physical Environment	3.24 (1.25)	4.00 (.94)	.69
	Classroom Behavior	2.65 (1.27)	3.88 (.99)	1.08
	Rapport	2.94 (1.03)	4.06 (.75)	1.24
	Reflection of Goals	2.41 (.80)	3.88 (.70)	1.96
Environment M (SD)		2.81 (.87)	3.96 (.87)	1.32
Teaching Performance Grand Mean(SD)		2.55 (.22)	3.91 (.09)	

Note. Low Evidence=0-1, Medium Evidence 2-3, High Evidence 4-5

The analysis for the results of the comprehensive teaching rubric presented the following effect size results for the criteria within the *active learning domain*: instructor delivery (*d* = 1.95), learner engagement (*d* = 1.91), instructor encouragement (*d* = 2.70), implementing activities (*d* = 1.64), and facilitation (*d* = 1.21). The analysis for the results of the comprehensive teaching rubric presented the following effect size results for the criteria within the *inquiry learning domain*: problem complexity (*d* = 1.15), questioning technique (*d* = 1.28), evidence and concepts (*d* = 1.38), and learner's arguments (*d* = 1.31). The sole contextual question yielded a medium effect size result (*d* = 0.66) from an analysis of the retrospective pre and post ratings by the graduate students as well as being noted as the lowest effect size result from the ratings on the entire LCT rubric.

Table 4.9 Domains and Criteria Summaries for the LCT Rubric

(*N* = 17)	Domain/Criteria	Pre-score *M (SD)*	Post-score *M (SD)*	Cohen's *d*
Active Learning	Instructor Delivery	1.71 (.77)	3.58 (1.12)	1.95
	Learner Engagement	2.24 (.97)	4.00 (.87)	1.91
	Instructor Encouragement	1.94 (.56)	3.65 (.70)	2.70
	Implementing Activities	2.18 (1.07)	3.94 (1.08)	1.64
	Facilitation	2.53 (1.07)	3.70 (.85)	1.21
Active Learning M (*SD*)		2.11 (.66)	3.78 (.67)	2.51
Inquiry Learning	Problem Complexity	1.82 (1.24)	3.18 (1.13)	1.15
	Questioning Technique	2.12 (1.32)	3.65 (1.06)	1.28
	Evidence & Concepts	2.29 (1.10)	3.65 (.86)	1.38
	Learner's Arguments	2.18 (1.24)	3.65 (1.00)	1.31
Inquiry Learning M (*SD*)		2.10 (.98)	3.53 (.79)	1.61
Contextual Learning		2.23 (1.52)	3.23 (1.48)	0.66
	LCT Grand Mean (*SD*)	2.14 (.07)	3.51 (.27)	

Note. Low Evidence = 0-1, Medium Evidence = 2-3, High Evidence = 4-5

4.3.2.3 Results for Research Question Two C:

The third and last of the beliefs and values sub-questions examined the graduate students' reflected and described beliefs and values from their reflection essays. Each of the reflection essays was examined qualitatively with regard to the theoretical framework of teaching self-efficacy and expectancy value motivation. Table 4.10 lists the selected construct from the teaching self-efficacy and expectancy value motivation theories: (1) teaching self-efficacy, (2) expectancy (3) attainment value/importance, (4) intrinsic interest/ intrinsic value, and (5) utility value. Motivational examples from each of the motivation constructs were utilized as focal points for the analysis. Exemplar examples of each construct from the theoretical framework were matched with samples of both summarized and *in vivo* coding from the study's participants essays. The summarized statements were collective meanings from multiple participants, while the *in vivo* were specific to a particular participant. Both samples were detailed to provide further clarification of how participant statements were reflected through the coding process. Pseudonyms were used to protect the identity of participants.

Participants' reflections related to teaching self-efficacy and expectancy constructs were distinguished by the coding of statements within the study. The researcher distinguished teaching self-efficacy as a more task and context specific expectancy belief. Thus, the researcher focused upon the study participants' teaching of a K-12 audience in regards to statements reflecting (a) an efficacy to engage, (2) an efficacy to make expectations clear, and (3) an efficacy for classroom management for current and future experiences. Conversely, reflection statements along the lines of general expectation or ability to do the task (i.e., teach K-12 audiences plant science) successfully were coded within the expectancy construct. Tschannen-Moran and Hoy (2001) note the individual evaluation of skills in efficacy expectation within social cognitive theory, whereas, expectancy may holistically recognize and evaluate outcome consequences for the entire teaching experience.

Table 4.10 Reflection Coding Examples

Motivation Constructs	Motivation Examples	Sample Coding of Summaries
Teaching self-efficacy	“Efficacy to engage with students” “Efficacy to make expectations clear” “Efficacy for classroom management”	The activity helped affirm a desire or ability to teach. (summarized) “I realized what the description of an effective teaching practice involved” (Emma)
Expectancy	“Ability to do the task” “Future success with this task”	The graduate students felt prepared to teach. (summarized) “In future work, I’m sure I’ll be involved in training and teaching” (Isabella)
Attainment value/ importance	“Doing well on a task” “Emphasis on success with task” “How important was the task”	The graduate students felt successful with the teaching experience. (summarized) “It was good to teach GMOs to students that didn’t know it” (Abigail)
Intrinsic interest/ intrinsic value	“Enjoyment value” “Enjoyment when doing the task” “Subjective interest”- (Personal interest)	Graduate students enjoyed sharing their science knowledge. (summarized) “I felt this was an excellent learning experience” (Mia)
Utility value	“Usefulness of task” “Relation to future goals” “Relation to career goals”	A good communication experience to help prepare graduate students for their future career. (summarized) “A valuable experience that is a good building experience for my career” (Aiden)
Cost belief	“Perceived negative aspect of doing task” “Worth doing whole giving up another choice” “Perceived amount of effort” “Anticipated emotional state”	It was difficult for graduate students to simplify complex science for young children. (summarized) “I spent a lot of time preparing for teaching the class.” (Mia)

The summary of the reflection essays was divided into two sections: (1) non-formal teaching experience and (2) formal K-12 teaching experience. The initial summary of results was derived from the descriptive coding. Within the descriptive coding, wording from *in vivo* coding phrases and concepts were used to illustrate graduate students beliefs and values. The provisional coding utilized the motivational provisional coding themes (self-efficacy and expectancy value motivation) to describe a summary of the students' reflections. The following sections reflect how the participants' essays reflected each of the motivation components.

4.3.2.3.1 Non-formal teaching experience reflection essay summary

Teaching Self-efficacy

Graduate students expressed various elements of teaching self-efficacy within their non-formal teaching experience summaries. A total of nine graduate students expressed comments related to concepts within teaching self-efficacy criteria. Overall, graduate students generally described their perceptions of their abilities to assist student learning with K-12 audiences through reflective comments relating to communication skills and techniques. Providing "succinct, clear, and direct" messages was directly stated by Mia as the best method to assure a participant's understanding. Madison recognized the self-efficacy to engage with audience participants as important.

> **Madison:** A good informal educator will be able to engage all the audience members, and help them become interested. Informal education is one of the most meaningful educations that a person can receive, and so it is important to participate in activities like these because children are exposed to so many different things in the world, and their minds are opened up to new ideas and concepts.

Individually, the extent to which graduate students perceived they could provide a learning environment for their audiences was distinguished by slightly varying reflections. Adapting questions for the abilities of the learner was woven throughout individuals' essays. Some graduate students perceived their abilities to teach by acknowledging the concerns they faced with the age of the children and the adults. Michael implied that upper elementary school-aged kids were the best to talk to during the non-formal learning experience. While William stated that "younger individuals have the light bulb moment" that can provide immediate feedback during the experience, he also stated that it was easier to discuss science with older youth and adults versus young children.

Several graduate students seemed to link their self-efficacy with teaching due to gauging the interest of the audience, however only two (Mia and Michael) spoke of sustaining it during the activity. Mia shared a story of speaking in depth with a mother and her young son, while Michael directed his responses to Spring Fest participants to include dispelling myths about genetically modified organism (GMO) research as it applied to their daily lives. Further, the attempt to manage the environment and the outside distractions could be related to the graduate students' feeling of confidence. Abigail recognized the ease of tying the concepts of the activities to current research. "I realized that it was not hard to find a way to incorporate my research into and activity, you just have to think of the basics of your research, not too in depth." While Emma was concerned about her general teaching ability, "I hope I can explain myself well enough."

Graduate students' awareness of their abilities to engage with the diverse members of an audience was varied by the descriptions of two self-perceived teaching environmental challenges. It was challenging for graduate students to adjust their novice teaching behaviors according to the quick pace for non-formal instruction. Secondly, it was challenging to link research concepts to a quick presumption of the audience's science knowledge. Mia's reflection encompassed both of these challenges by detailing the difficulty of talking about science with the continuously changing audience at Spring Fest.

> **Mia:** I was able to gain experience managing a busy situation to ensure that it was meaningful for the children and adults that stopped by. Moreover, I learned to gauge an audience, their interest and educational level, and attempt to cater the lesson to their needs. Hopefully, this allowed for the maximum efficacy of the booth.

The recognition of changing the difficulty of the matches for the one activity at Spring Fest to match the perceived level of ability of the audience was noted with confidence by Aiden. Ava stated that the "student and researcher contact is an important link" versus "just reading about plants in a book." In summary, graduate students described their developing teaching self-efficacy through time-limited interaction with varying audiences. Often, graduate students gauged their teaching self-efficacy development according to their communication techniques and skills to engage within these particular non-formal experiences.

Expectancy

Expectancy was a specific component of teaching self-efficacy examined separately within the graduate students' reflection essays. Unlike outcome expectancy, which focuses on the outcome expectation of a particular behavior, expectancy within this study was focused upon the belief graduate students developed concerning their teaching behaviors. Graduate students more often stated their perceptions of teaching ability in their reflections of the non-formal experience rather than the expectancy of their teaching ability to do the task or the future success with the task. In comparing her youth religious teaching experience to the Spring Fest experience, Mia noted a realization of a confidence difference due to the pace of Spring Fest. Graduate students described a positive link of using agricultural themes throughout their non-formal experiences to enable them to connect with the non-scientific audiences. For example, Michael was surprised at how well the group was able to develop concepts from his group's diverse plant research areas into collective activities that were perceived to be fun. Sophia stated that volunteer outreach activities were a great way for graduate students to further future connections with the next generation of scientists. William, Mia, and Abigail expressed the belief of practicing outreach techniques now as influential toward their skill development for future communication tasks. In summary, graduate students described their awareness of teaching as important to potential future careers, but provided fewer comments when describing or predicting their future success with LCT teaching strategies after their non-formal experiences.

Attainment value/ importance

Graduate students varied in their descriptions of concepts identified as attainment value or importance in the reflections of the non-formal teaching experience. A total of 11 graduate students expressed comments related to concepts within the attainment value criteria. Graduate students who alluded to English as a second language were expressive about overcoming the language barrier and expanding their use of common terms as compared to the extensive use of technical terms used within the laboratory setting. These graduate students seemed to identify the success of the task in reference to their speaking ability.

> **Anonymous[1]:** The language has always been one of my biggest concerns in activities like this one. You need to use a different vocabulary; you are not talking with other students or professors. For an international student it is always a challenge. During the day, I completely forgot about the difference in language.

Regardless of international or domestic status, overall, the graduate students spoke of success and satisfaction with their non-formal teaching experience. The importance of doing well with the non-formal teaching experience was evident by a variety of comments. Aiden, Ethan, and Olivia expressed the importance to try to understand peoples' educational and comprehension abilities as a reflection of their attainment.

> **Aiden:** Honestly, I was worried that the activity would be underwhelming and boring to kids. Most adults I've known have a short attention span when the topic is plants and they don't have a strong vested interest. My worries were unfounded.

Jacob and Ava conveyed the importance to connect with the audience through shared interests and suggested career opportunities.

> **Ava:** These kids (3rd grade students at a rural school) are not exposed to Purdue students very often, but they looked up to me because I am one. Other graduate students could also encourage the younger generations by giving their time to a volunteer activity. The communication of future graduate students will be a key to increase the attendance of plant breeders in post-secondary education.

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[1] Anonymous was used to assure the participant's anonymity due to few international participants

Olivia, Mia, and Emma alluded to an importance to do the job to get even the shy youth involved. Which differed slightly from the William and Noah's predominate focus of conducting the simple activities to present research concepts to a diverse audience.

> **Noah:** It can be difficult to relay complicated information to an audience, but using simple activities with a simple message proved to be the most efficient and appropriate method of introducing the material and concept. A simple message for my audience is the best way for anyone to relate to a general audience and convey a simple message.

Madison, Mia, Ethan, and Abigail expressed frustration with audience members that seemed to be only participating in the activities to get the free item as opposed to being interested in knowledge and why the audience should care about knowing the information.

> **Madison:** I was surprised how much I struggled with talking to people that appeared to have no desire to learn about plants, and to only want a flower. I probably was just assuming that they had no interest, but I should not have been thinking that way in the first place. I would just make the flowers for the people and do it as fast as possible because it seemed like they were impatient and wanted to leave as fast as possible.

Abigail expressed a cohesive summary of the personal attainment and importance value suggested by many of the graduate students.

> **Abigail:** To grow as a researcher, one must be able to talk about their research to people who might not quite understand it. And with this experience in particular, I had to teach these people in a small amount of time so I had to make sure to get my point across. While getting the experience to do this, I think I grew as a researcher.

In summary, graduate students described individual and group successes based upon personal and group goals for the non-formal teaching experiences. When the actions of audiences within the non-formal teaching experience matched the graduate students' learning goals for the outreach experience, the graduate students' reflections were described as successful.

Intrinsic interest/ intrinsic value

A majority of coded themes from the graduate students' non-formal teaching reflection summaries revolved around the graduate students' intrinsic interests or intrinsic value. Overall, graduate students had positive experiences and enjoyed sharing their personal interests in plant sciences with youth and adults. A total of 14 graduate students expressed comments related to concepts within intrinsic value or interest criteria. Graduate students' level of interest or enjoyment was identified with various descriptors. Graduate students from the first cohort were given the opportunity to select to volunteer at an existing youth event for their non-formal teaching experience. Graduate students in the second cohort designed and conducted activities according to the group's decisions. Graduate students from both cohorts expressed enjoyment in the various activities due to the general topic of the activity. Emily stated, "Horticulture CDE was a refreshing experience for me." While, Olivia stated, "I enjoyed this experience. I was never involved in FFA (in high school)." Michael more directly stated, "I personally enjoyed when I worked at the station where the students were asked to pair the seeds with their center of origin."

Several graduate students identified with an enjoyment of participating in the activity due to the age of the audience participants. Aiden, Ava, Sophia, and Ethan expressed the gratification of working with the younger audience members.

> **Aiden:** I was amazed at how enthusiastic many of the kids were, even the smaller ones. They seemed really happy to get a match right, which was neat to see. I tried my best to congratulate each of them on the right answers and be patient with the kids who struggled.

Liam and Noah conveyed an enjoyment of communicating with high school students and adults.

> **Liam:** I also enjoyed the one-on-one interaction with FFA students and talking to them candidly about potential education and career opportunities. In particular, I was able to talk to one college student who was interested in graduate school.

By the same token, William and Isabella enjoyed the entire audience, regardless of age.

> **Isabella:** I actually enjoyed playing and teaching young kids. I also really enjoyed interacting with education graduate students and learning about their projects and their future plans.

Mia, Abigail, Emily, Isabella, Ethan, and Ava pointed out the passion they have for plant science and agricultural literacy. Emily stated that she enjoys “mingling with others who have a passion for plants.” While, Ethan remarked, “The love of plant study in my field helps me motivate others to learn more about agriculture.” Abigail further distinguished her interest to educate those with a less modern agricultural background.

> **Abigail:** I love explaining my research to other people. It makes me feel good about what I am doing and it also gives the listeners an idea of what is going on in the world of agriculture. I also love explaining my research because not many people know much about agriculture, other than corn and soybeans.

In summary, graduate students expressed their value of the experience through reflections of utilizing autonomous opportunities to share their passion for plant science with audiences of varying ages.

Utility value

The second most coded themes from the graduate students’ non-formal teaching reflection summaries revolved around the utility of the teaching experience. The usefulness of practicing communication techniques to disseminate science knowledge through the non-formal teaching experience was detailed throughout 11 of the reflection summaries. Furthermore, graduate students expressed the usefulness of revisiting previous basic plant science concepts they learned as undergraduate students. Emily stated how “it gave me a chance to refresh my memory about horticultural plant identification and other practical aspects of plants.” Olivia and Ava reminisced how their previous youth learning experiences were similar to this teaching experience and may have led to their desire to study in plant sciences.

Graduate students distinguished obtaining and practicing skill development as being an important utility value. Abigail pointed out how she “developed/enhanced many skills while working on this event including (her) teamwork, leadership, communication and time management skills." Michael determined that his "greatest increase to (his) skill set to come from (the event) was the increase to (his) patience." The development of these skills was self-reflected practice for their current and future career goals. Sophia stated the career relation of a meeting with a volunteer scientist at a school science fair. "It was really interesting learning about what he does for a living and why he continues to judge science fairs." Ethan described the usefulness of the outreach teaching to his personal goals as he had "never planned an activity for children before." Graduate students further recognized the usefulness of reducing the information into simple or basic concepts as the best method for them to start describing their research when approaching the development of outreach for non-science types of audiences. Aiden summarized his experience as "the importance of reducing a message to a few simple, easily sensed and illustrated concepts really stood out to me, more than anything else, during my reflections on the experience of Spring Fest." Furthermore, Madison spoke of her continued interest to "learn to take advantage of moments of informal education so that I can have more impact on other people's lives." And Noah spoke specifically how this experience could impact his and fellow graduates' future career projects.

> **Noah:** I consider this experience would help me in deciding my future projects to address specific problems and requirements of the farming community. Other graduate students should participate in these kinds of activities to get a personal feel of what farmers require, how to communicate with farmers, attract their attention, and get ideas from their real-life problems.

In summary, graduate students described specific characteristics of the non-formal teaching experience as being useful to their personal career goals. The characteristics reflected components of 21st Century Skills.

Cost belief

In contrast, graduate students distinguished very few cost beliefs in regards to their participation within the non-formal teaching experience. A total of seven graduate students expressed comments related to concepts within the utility value criteria. Emily stated that although she enjoyed her experience, her volunteer experience had "no direct relation to her research." Liam indicated a similar disappointment of not sharing as much scientific knowledge as opposed to facilitating general graduate school questions. Conversely, Ethan stated that he was glad a fellow graduate student with greater crop specific knowledge was working alongside him to assist with questions he couldn't answer and feared the appearance of looking unintelligent. The potential for a negative experience was noted by others. Much of the comments seemed to be shared by students who felt they would not have sounded scientific enough through using different words than what is used in research. Thus, the graduate students perceived a negativity of making the graduate student sound less intelligent. In summary, graduate students in Cohort 1 (i.e., those simply volunteering at an established event) expressed more cost beliefs than Cohort 2. Both cohorts, overall, shared enjoyment and utility statements of the non-formal teaching experience.

4.3.2.3.2 Formal K-12 teaching experience reflection essay summary

Teaching Self-efficacy

Graduate students expressed various elements of perceived teaching self-efficacy within their formal K-12 teaching experience summaries. A total of 15 graduate students expressed comments related to concepts within the teaching self-efficacy criteria. Graduate students responded with mixed feelings about sustaining an interactive and engaging learning environment. Madison, Liam, Aiden, and Ethan described the reflective development of their beliefs for engagement with K-12 students in a classroom setting. Liam and Madison recognized the opportunity and sometimes missed opportunity to connect with students on an individual basis to provide a more personalized learning experience.

> **Madison:** We missed an opportune time to develop a communicative relationship with the students, and to get them involved from the beginning. We shouldn't have ignored the activity. Instead, we should have started a verbal conversation with them about the differences they saw and what they thought caused the differences.

> **Liam:** While we were a little discouraged at first, this presented a good opportunity to work with the boys on a much more personal level and allowed us to closely monitor their reactions to our teaching style. This allowed us to make adjustments to better meet their needs.

In contrast, Aiden and Ethan reflected upon the belief they developed when working to engage a larger group.

> **Aiden:** I believed the students would connect more strongly with topics they could observe in their own neighborhoods. I engaged students during this portion of the course by asking questions related to the topics or their own experiences.

Mia, Olivia, Emma, Aiden, Isabella, and Abigail described their capability to employ clear expectations throughout their reflection essays. Graduate students detailed their intentions to refer to the fundamental points of important science concepts. However, the communication of these concepts left graduate students sometimes commenting about how to plan for the communication of these concepts properly. Several graduate students relied on continually reinforcing their concepts with questions referencing previously learned biology. Likewise, graduate students expressed their confidence in teaching and belief in additional formal professional development as an effective method to positively assist with their teaching skills. Isabella, Mia, and Olivia reflected a form of clarity through their believed ability to explain terms, concepts, and synthesis process with the material that was presented within their lessons. Descriptive terms relating to reviewing standards or critical thinking were used to justify a status of clarity within the experience.

> **Isabella:** We followed Indiana's academic standard for science for 4^{th} grade to prepare our presentation. The reason behind this is to make sure they learn the fundamental reason behind doing this experiment and also so they learn about the key terms associated with basic genetics.

Abigail, Emma and Aiden reflected a more general notion of clear expectations alluded to by many of the graduate students in the teaching experience.

> **Emma:** During the class, I realized what the description of effective teaching involved. This teaching experience helped me to understand the efficacy that a lesson with active learning can have…as they challenged us to use all the resources that we created for them.

Moreover, graduate students spoke of their navigation for classroom management and how their perceived thoughts have somewhat been altered. The varying teaching environments created a host of educational environments that were diverse with audience characteristics and academic surroundings. Classroom procedures, behavior and the existing learning environments were noted by a few graduate students as challenging but also manageable due to their course training and classroom K-12 host teacher. William recalled the "classroom dynamics as challenging." Adaptations to accommodate the challenges were noted by graduate students as a method of engaging the K-12 students. Feelings about graduate students' abilities throughout the experience were reflected as confidence about lesson progression, worried and slightly nervous about timing of moments within the lesson.

> **Michael:** The other issue that I experienced was that I didn't know the classroom procedure that the (K-12 classroom host) teacher had introduced to bring the class back to attention. She was very effective in doing this, and had I known what her common practices were this probably could have went slightly smoother.

In summary, graduate students described their development of teaching self-efficacy with a perceived ability to engage the K-12 students through their plant science lessons. Graduate students shared they felt self-efficacious based on their observations that K-12 students could readily understand and apply plant science knowledge during their lessons.

Expectancy

In contrast to the previously stated beliefs of teaching self-efficacy, the expectancy elements within this section focused specifically on the graduate students' perceived ability to do the general teaching task and potential for future teaching success. Overall, graduate students stated positive comments about their abilities to complete the formal K-12 teaching experience throughout their reflection essays. A total of 12 graduate students expressed comments related to specific concepts within the expectancy criteria. Ava's general observation about her audience's enthusiasm for her classroom presence but mixed levels of plant science knowledge was consistent throughout many of the other graduate students' reflections essays. Nevertheless, graduate students described their beliefs through specific situations and self-discoveries.

> **Jacob:** I wanted the high school boys to realize what someone with education in plant genetics can do. I tried to include many visuals and real-life stories of researchers and plant breeders. It is easy to forget that many students do not have an agricultural background. This experience helped me to think who is the audience for future presentations.

Sophia specifically stated that she, "felt like she was well prepared to teach the lesson." Likewise, Mason stated, "I knew beforehand exactly what to expect in the classroom setting, (yet) I was nervous initially." And Michael described his educational growth from a misconception of audience characteristics due to location.

> **Michael:** I had many notions and ideas of both how the class would act in general at that age level, as well as how attentive they would be to the material we were presenting. I was only concerned about this fact because we were presenting information on agriculture and these kids are from an urban setting and many of them have probably never been to a farm. I was surprised when both of these notions were proven to be false.

Furthermore, graduate students described positive goals for future successes with using teaching skills in similar or adapted environments, such as Extension or University outreach programs. Aiden commented on his comfort level for teaching plant science and noted, "if he were to teach a similar class in the future" he had already determined adjustments to the planned lesson. Emma stated that "effective teaching is not only about the knowledge that you want to transmit" but the entire process to successfully get your message to be understood. In summary, the graduate students spoke confidently about their abilities to teach, in general, in the future along with expectations of continued development and success with teaching opportunities.

Attainment value/importance

Graduate students described various elements of perceived attainment value or importance within their formal K-12 teaching experience summaries. Similar to the response in the teaching self-efficacy criteria, a total of 15 graduate students expressed comments related to concepts within the attainment value criteria. First and foremost, graduate students' described an emphasis on successfully completing the teaching task. The graduate students identified their successes most often by observing the positive reactions of K-12 students in their classrooms. The excitement, interest, and positive responses expressed by facial responses and actions of the grade school students were noted within the graduate students' reflection summaries. Mason stated that he was pleased to see the "students' reactions of excitement and overall interest." The extent of graduate students' perceived identification of success was noted by some through receiving follow-up correspondences with their K-12 classroom host teachers.

> **Ava:** I received feedback from their (K-12 classroom) teacher that the seeds had sprouted and that the students were excited to see the shoot and roots growing out of the seed. Some still wanted to conduct their own experiment and see how long they can grow their mini plants in a baggy! This was a great exercise for this age group.

Brief comments by many of the graduate students detailed the importance of the teaching task. Noah, Ava, Mia, Emily, Olivia, and Aiden alluded to a perceived importance of teaching throughout their reflection essays. Emily stated that it was good to be able to "make a small but significant change in the perspective of students" with plant science. Mia extended the importance of the teaching to include how the experience helped "force her to deepen her (own) understanding of science" to be able to answer questions posed by the grade school students.

The perceived emphasis by graduate students to do well on the task was infused with their self-determined importance of the content material. Emily, William, Mason, and Emma shared subtle descriptions of this threaded within their reflections in contrast to the specific statements found in Abigail's reflection essay.

> **Abigail:** It feels good to be able to teach students about a subject that they are not familiar with and having the opportunity to have them learn new stuff. It is important to teach about GMOs to the students. GMOs are becoming a big controversy all over the world. Many people are scared about what these plants will do to our health and our environment, but these people do not know much about the process of how GMOs are created.

In summary, plant science graduate students not only described a desire to be successful with the formal teaching experience, but also the value of the teaching experience for both the graduate student and the K-12 audience. The graduate students determined their successes in the experience based on visual responses of the K-12 audiences.

Intrinsic interest/intrinsic value

The motivational component with the most comments from the graduate students' formal K-12 teaching reflection summaries revolved around the criteria of intrinsic interest and intrinsic value for the teaching experience. The graduate students' interests and values of the experience were based on their enjoyment of presenting the plant science subject material and the K-12 audience characteristics. Overall, graduate students described the classroom teaching experience as a challenging, yet, fun learning experience.

Aiden, Jacob, Ethan, Isabella, Sophia, Michael, and Ava expressed the enjoyment of the age group that they taught. Sophia stated, "Teaching the young grades was fun." The graduate students who were in an elementary and middle school classroom settings tended to make more and sometimes multiple enjoyment comments throughout their reflection essays.

> **Ethan:** I like to share my scientific knowledge with children. Every time I explained to them the rationale behind the phenomenon, I could see the surprises on their face and smiles after the confusion was solved. I love to talk to kids, because I think their imagination is always beyond your intelligence.

Graduate students also expressed their enjoyment of the task by sharing lessons infused with research concepts, sharing scientific knowledge as applied to real-world situations, and sharing actual lab-like experiences. Mason, Mia, Emma, Liam, Jacob, Aiden, and Ethan interjected short statements throughout their reflection essays that combined the belief of their personal interest through the interest feedback they observed with their K-12 audience members.

> **Mason:** I was very active from the beginning in planning and organizing this outreach opportunity. I took responsibility for most of the background information and put together slides from the basics of living organisms, to what is a cell and what are the components of a cell, to introducing the idea of what is DNA. I was excited for the opportunity and found it challenging yet motivating to incorporate past experiences with the subject matter, developing some simple, yet

> thought provoking questions for the students to keep them actively engaged, and relying on popular social/animal figures that they can relate to everyday to help explain the topics.

Additionally, graduate students' personal interest was emphasized through comments related to designing the lesson with the basics of their research as the topic of the lessons. Abigail stated, "I enjoy sharing information about GMOs." And Madison identified, "I like sharing information that I already know and hearing their interpretation of the facts." Multiple graduate students stated that they would recommend the experience to new graduate students. In summary, graduate students described their enjoyment of the experience through the opportunity to share their personal interests in plant sciences. Moreover, graduate students expressed an enjoyment from the formal teaching experience based on having a sense of autonomy in choosing the topic, activity, and audience.

Utility value

Graduate students' perceptions of the utility of the K-12 teaching experience varied among the reflection summaries. William, Ava, Mia, Abigail, Madison, Isabella, Aiden, and Ethan expressed how this teaching experience would not be their last. Ethan, Aiden, Madison, Ava and Abigail elaborated by stating that teaching would play a role in their careers in the future.

> **Isabella:** Being an aspiring plant breeder, it was great explaining to the young students about basic genetics in very simple terms. In the future, whether I work for an industry or in academics, I am sure I will be involved in teaching and training future plant breeders, producers, and growers.

Graduate students reported the importance of utilizing different communication skills as a benefit of participating in the K-12 teaching experience. Emma, Olivia, Mia, and Madison described how learning to communicate with K-12 students would not only help them practice effective communication, but also help them determine additional ways to communicate science to individuals outside their labs.

> **Madison:** I think learning to teach is a very valuable skill no matter which career a graduate student wants because a person is always teaching. Teaching occurs in

> the classroom, the office, the lab and at home. It takes skills to recognize a student's learning methods, and to adapt your teaching to those methods.

In addition, graduate students perceived utility elements of the experience in relation to their graduate student careers goals. Mason stated that he could now see this experience as a "springboard" for pursuing career opportunities that may include educational instruction within job descriptions. Similarly, Sophia, Mia, William, Aiden, and Madison viewed the experience as a positive personal development experience, especially in learning how to observe K-12 students to recognize the needs of an audience.

Furthermore, graduate students described the usefulness of the teaching task in relation to science literacy within and for society. The graduate students' elaborated on a motivation to educate K-12 students about the value of these graduate careers in relation to the future of the food supply and society in general. Isabella stated, "It's good to help students understand genetics for their lives." While Mason, Ava, and Michael stressed the need to encourage students to enter careers in agriculture and continue to educate the next generation to understand the science behind the decisions about food. In summary, graduate students described varying utility of the formal teaching experience as a graduate student and for future careers. Graduate students also expressed an intention to use the skills developed within the formal teaching experience in future teaching opportunities.

Cost belief

Graduate students described few cost beliefs associated with participating in the K-12 teaching experience. Five graduate students expressed comments related to concepts within the cost beliefs criteria. Sophia and Olivia distinguished the "hardest part" or most difficult part of the teaching experience as the planning of lessons and activities, especially for an elementary audience. Olivia elaborated with the perceived feeling of being treated as though she was preparing to teach elementary school versus the status of a graduate student studying in a complex science field.

> **Olivia:** I do not like the way this course treated us as if we were preparing to be elementary school teachers. We are not. We are here studying plant genetics and breeding. If our career plans included elementary school education, you would find us over in the College of Education and likely not in graduate school in the first place.

Mason and Mia commented on the time required to memorize content for the K-12 teaching engagements. Mia also noted the emotions of continuously readjusting due to a K-12 experience that didn't quite match her graduate student's mental plan for the teaching event, especially after spending considerable time preparing for teaching the class. William stated that although the "classroom experience was fun and interesting," it was "not necessarily useful in (his) future career." In summary, the graduate students described costs beliefs regarding the formal teaching experience as additional work, possibly taking away from their academic and research responsibilities. Moreover, some high achieving graduate students shared a personal challenge to excel at performing teaching tasks with similar results as their academic and research efforts.

4.3.3 Results for Research Question Three:

For the third research question, a follow-up questionnaire and video interviews were conducted a year after the plant science graduate students completed the K-12 integrated training experience. The findings reflected the described beliefs and values of graduate students from the K-12 experience regarding personal graduate experience, career readiness, and science literacy. The follow-up teaching self-efficacy and 21st Century Skills results were presented prior to the summarized and analyzed video interviews. Lastly, an engagement ordered matrix was used to depict an overall summary of the data from the research study. Pseudonyms were used to protect the identity of participants.

4.3.3.1 Follow-up questionnaire self-efficacy results

Graduate students completed a follow-up self-efficacy questionnaire a semester after the last group of students completed their K-12 outreach teaching experience. Teaching self-efficacy scores of graduate students from the follow-up questionnaire depicted graduate students felt “Quite a Bit” self-efficacious with teaching (Table 4.11) with an overall mean of 3.98 (*SD = .28*). The follow-up teaching self-efficacy scores had a large effect size (*d* = 1.19) from the initial graduate students’ initial teaching self-efficacy scores of 3.58 (*SD* = .38). This difference is descriptive and cannot be interpreted as a cause-effect relationship. Graduate students rated themselves with predominately “quite a bit” of teaching self-efficacy on all but four of the items. The question with the lowest overall rating for teaching self-efficacy was the writing of learning objectives using Bloom’s Taxonomy. This was the only question to receive a rating of zero ability from at least one graduate student. Graduate students rated themselves most highly (always/a lot) with creating an interactive learning environment (46.7%) and bringing real-life experiences to the classroom (53.3%).

Table 4.11 Delayed Posttest Teaching Self-Efficacy

Teaching Self-Efficacy Items *N = 15*	None	Very Little	Some	Quite a bit	Always/ a lot
How much can you influence student learning?	0	0	1 (6.7%)	8 (53.3%)	6 (40.0%)
How much can you challenge students to think more critically?	0	0	2 (13.3)	9 (60.0%)	4 (26.7%)
How much can you motivate students to participate in class activities?	0	0	2 (13.3%)	9 (60.0%)	4 (26.7%)
How much can you engage students to work as a team?	0	0	4 (26.7%)	8 (53.3%)	3 (20.0%)
To what extent can you create an interactive learning environment?	0	0	1 (6.7%)	7 (46.7%)	7 (46.7%)
To what extent can you bring real-life experiences to the classroom?	0	0	0	7 (46.7%)	8 (53.3%)
To what extent are you prepared to teach the K-12 class you taught?	0	0	4 (26.7%)	9 (60.0%)	2 (13.3%)
To what extent can you clearly communicate the content so students will understand?	0	0	2 (13.3%)	11 (73.3%)	2 (13.3%)
To what extent can you make students believe they are able to learn and apply the content?	0	0	6 (40.0%)	7 (46.7%)	2 (13.3%)
To what extent can you adjust your teaching to accommodate different learning styles of students?	0	0	5 (33.3%)	7 (46.7%)	3 (20.0%)
How effectively can you facilitate an engaging class discussion?	0	1 (6.7%)	4 (26.7%)	8 (53.3%)	2 (13.3%)
To what extent can you incorporate different teaching methods in your lessons?	0	0	2 (13.3%)	9 (60.0%)	4 (26.7%)
To what extent can you make your expectation clear to students?	0	0	2 (13.3%)	7 (46.7%)	6 (40.0%)
To what extent can you write clear learning objectives using Bloom's taxonomy?	1 (6.7%)	2 (13.3%)	6 (40.0%)	4 (26.7%)	2 (13.3%)
To what extent can you design learning activities to help students to learn the content?	0	0	4 (26.7%)	8 (53.3%)	3 (20.0%)
How effective can you provide alternative explanations to clarify the main idea?	0	0	4 (26.7%)	6 (40.0%)	5 (33.3%)
To what extent can you apply different assessment methods beyond a knowledge test?	0	1 (6.7%)	5 (33.3%)	6 (40.0%)	3 (20.0%)
To what extent can you provide students with specific feedback about their performance to help them learn?	0	1 (6.7%)	3 (20.0%)	8 (53.3%)	3 (20.0%)

Table 4.11 Continued

To what extent do you think your students would score well in the exams due to your teaching?	0	0	5 (33.3%)	9 (60.0%)	1 (6.7%)
To what extent would your students be able to apply the concepts learned in class to real-life situations?	0	0	5 (33.3%)	9 (60.0%)	1 (6.7%)
To what extent do you feel this series of courses has adapted your view of teaching?	0	1 (6.7%)	1 (6.7%)	8 (53.3%)	5 (33.3%)
To what extent do you feel this series of courses would be beneficial to other graduate students in the college of AG	0	0	4 (26.7%)	6 (40.0%)	5 (33.3%)
To what extent do you feel this teaching experience will assist you in your future career?	0	1 (6.7%)	2 (13.3%)	8 (53.3%)	4 (26.7%)
To what extent did you feel the outreach experience (volunteer experience-Spring Fest) will assist you in your career	0	1 (6.7%)	6 (40.0%)	6 (40.0%)	2 (13.3%)
To what extent do you feel the Extension education experiences will assist you in your future career?	0	0	1 (6.7%)	8 (53.3%)	6 (40.0%)
To what extent do you feel educating PK-12 audience is important to your professional career?	0	2 (13.3%)	3 (20.0%)	7 (46.7%)	3 (20.0%)
Grand Mean = 3.98 SD = .28					

Note. 1 = None, 2 = Very little, 3 = Some, 4 = Quite a bit, 5 = Always/ A lot

4.3.3.2 21st Century Skills results

Additional questions about graduate students' perceived practice of 21st Century Skills in conjunction with the K-12 teaching experiences were added at the end of the follow-up questionnaire (Table 4.12). The questions were divided into four sections: (a) critical thinking and problem solving, (b) creativity and innovation skills, (c) communication and collaboration skills, and (d) life and career skills. The average for graduate students' responses within the critical thinking and problem-solving skill domain were on the high end of the "Some" option *(M = 3.78; SD = .17).* The average for graduate students' responses within the creativity and innovation skill domain were on the high end the "Some" option *(M = 3.98; SD = .19).* Overall, graduate students responded positively toward using multiple 21st Century Skills after having completed the K-12 outreach teaching experiences with a mean of 3.95 *(SD = .22)*. Graduate students reported low perceived ability to "use systems thinking" after having completed the K-12 teaching experiences. Graduate students reported high perceived ability to "work creatively with others" and "manage projects" after having complete the K-12 teaching experience. Graduate students' responses varied more across the response choices in regards to the subgroup "guide and lead others" than any of the other subgroup areas. In comparison, the graduate students on average selected "Quite a Bit" as the response for the extent they felt the K-12 outreach experience helped them practice skills within the *communication and collaboration* domain *(M = 4.13; SD = .20)* and *life and career* domain *(M = 4.04; SD = .20).*

Table 4.12 21st Century Skills

Teaching Follow-up 21st Century Skills Items & Subgroups *N = 15*					
To what extent do you feel the K-12 outreach experience helped you practice the following 21st century critical thinking and problem solving skills. (M = 3.78; SD = .17)					
	None	Very Little	Some	Quite a bit	Always/ a lot
Reason effectively	0	0	5 (33.3%)	7 (46.7%)	3 (20.0%)
Use systems thinking	0	1 (6.7%)	7 (46.7%)	6 (40.0%)	1 (6.7%)
Make judgments	0	0	4 (26.7%)	8 (53.3%)	3 (20.0%)
Make decisions	0	0	5 (33.3%)	7 (46.7%)	3 (20.0%)
Solve problems	0	0	4 (26.7%)	9 (60.0%)	2 (13.3%)
To what extent do you feel the K-12 outreach experience helped you practice the following 21st century creativity and innovation skills. (M = 3.98 SD = .19)					
	None	Very Little	Some	Quite a bit	Always/ a lot
Think creatively	0	0	4 (26.7%)	9 (60.0%)	2 (13.3%)
Work creatively with others	0	0	1 (6.7%)	10 (66.7%)	4 (26.7%)
Implement innovations	0	0	4 (26.7%)	9 (60.0%)	2 (13.3%)
To what extent do you feel the K-12 outreach experience helped you practice the following 21st century communication and collaboration skills. (M = 4.13 SD = .20)					
	None	Very Little	Some	Quite a bit	Always/ a lot
Communicate clearly	0	1 (6.7%)	3 (20.0%)	7 (46.7%)	4 (26.7%)
Collaborate with others	0	0	1 (6.7%)	9 (60.0%)	5 (33.3%)
To what extent do you feel the K-12 outreach experience helped you practice the following 21st century life and career skills (M = 4.04 SD = .20)					
	None	Very Little	Some	Quite a bit	Always/ a lot
Interact effectively with others	0	0	1 (6.7%)	10 (66.7%)	4 (26.7%)
Work effectively in diverse teams	0	0	4 (26.7%)	8 (53.3%)	3 (20.0%)
Manage projects	0	0	3 (20.0%)	7 (46.7%)	5 (33.3%)

Table 4.12 Continued

Guide and lead others	0	2 (13.3%)	4 (26.7%)	5 (33.3%)	4 (26.7%)
Be responsible for science education to others	0	0	1 (6.7%)	10 (66.7%)	4 (26.7%)
Grand Mean = 3.95 *SD* = .22					

Note. Scale: 1 = None; 2 = Very little; 3 = Some; 4 = Quite a bit; 5 = Always/A lot

4.3.3.3 Follow-up interviews

Follow-up interviews were conducted with four graduate students using a semi-structured interview protocol. The initial summary of the transcribed data were derived from holistic and *in vivo* coding. Provisional coding utilized the previously established motivational coded themes (self-efficacy and expectancy value motivation) to organize patterns and relationships across the participants' responses. Additionally, the summary of the interview data was divided into three provisional sections: (1) personal graduate student experience, (2) career readiness, and (3) science literacy.

4.3.3.3.1 Personal graduate student experience summary

Graduate students participating in separate interviews reported a variety of teaching experiences prior to the integrated graduate teaching experience. Noah stated he had no experience with teaching K-12 students prior to his enrollment in the K-12 outreach courses. William and Aiden described brief teaching experiences with K-12 students. Their previous teaching experiences were described as non-formal and required no instructional planning. Ava described multiple non-formal teaching experiences with K-12 audiences in conjunction with a variety planning opportunities prior to enrolling in the integrated graduate teaching experience. The graduate students' initiative to participate and personal rewards from participation varied for each student. Ava spoke fondly of her early teaching experiences with youth as a youth educator and then varying experiences between positive and challenging with undergraduates as a teaching assistant for lab courses.

> **Ava:** So I am used to those age groups (K-12 age audience) and I like those age groups and I love coming up with creative exercises to learn something. So it's kind of like how I'm wired anyway…not that I am a super aggressive person in the classroom or anything, but given my experience level at the time maybe I don't know. I think there were classes where, all of students and me just meshed perfectly, they loved me, and they thought I was great. And then the next semester I had a class where like nobody really seemed to like me, we didn't mesh very well. I think that was the first time I've ever experienced that and any teacher anywhere will tell you certain semesters you just mesh with the students and the next semester you may not.

Aiden spoke generally of sporadic outreach teaching opportunities as an undergraduate, while William's identification of a lengthy non-formal experience during his time as a high school student provided a glimpse of the difference between graduate students' early personal rewards with teaching.

> **William:** I did do some peer mentoring when I was a kid, for three years actually with an autistic student, basically I'd just hang out with him, try to get him to have a conversation. Was it good for me, it was a good way to get out of class rather than to actually sit there, if I honestly just look back at my high school past.

Upon completing at least one year of graduate school, all interviewees had experienced some form of teaching as a teaching assistant (TA) within their academic department. Aiden was the only graduate student to address the preparatory opportunities provided to graduate students prior to employment as a TA. He stated he attended the "TA training thing at the beginning when you first come to Purdue as a grad student, but it's like two days and you forget it all within a month."

Throughout the interviews, all graduate students spoke of a personal interest within their plant science discipline. Ava and William described their passion for agriculture through shared experiences with family and friends who are directly involved in fiber and food production.

> **William:** I grew up in a (Midwestern state), everything was in the purview of agriculture. I grew up with a family that farms a lot. I had the background of it so; I love 4-H and FFA. I just never participated in it.

Aiden and Noah spoke of their enjoyment when conversing about plant science topics with others outside of their usual research circles. In reference to his K-12 teaching experience, Noah relayed how he felt an "enjoyment when the students are learning (about plants)" from teaching children. He hoped that he had inspired them to possibly attend college for a degree in agriculture. Likewise, Aiden spoke about the ease of conversing with non-academic individuals who have a shared interest in plant science. "The walnut guys are really easy to work with, yeah just because they do love trees, so much," said Aiden.

All interviewees described an enjoyment from participating within the non-formal and formal integrated teaching experiences. The enjoyment descriptions included watching the K-12 students "eyes light-up with excitement" (Ava) or the high school individual's "smile of understanding" (Noah). These actions in turn were unknowingly facilitating the teaching self-efficacy thought process by interviewees. Interviewees spoke of their abilities to engage with the variety of audience members in both experiences. And while, William, Aiden, and Ava spoke of previous public speaking training or practice as a precursor to feeling confident in front of varying audiences, they all seemed to discern a personal ambiguity with their confidence. William noted how the confidence developed from work with previous professors provided him a basis for preparing to be confident to teach on his own.

> **William:** I just had the most confidence that he had prepared me for what we were going to do that day (teaching undergraduates)… we were prepared; we are going to talk about it. They are going to ask questions. The third graders still ask tough questions (teaching K-12).

Although Ava had previously taught young children for several years in a non-formal youth setting, she stated that she wasn't very confident in her abilities when she started teaching undergraduates as a TA. Aiden described how his level of confidence for teaching any audience related directly to how (1) knowledgeable he was with the content, and (2) his familiarity with the type of audience. He further described how he perceived an increase his abilities in regards to the audience response.

> **Aiden:** Yeah that's the other thing is the, if you don't do it right the consequences are worse, with K -12 kids, because they'll start misbehaving probably or whatever; they'll be obviously disinterested, but if they are really interested they will express it, you'll definitely be able to tell if they are really interested in what's going on. Whereas with undergraduates or adult audience is they may not make it obvious that they are uninterested, but even if you gave really a great presentation there is not a good chance that they would be extremely enthusiastic. There is a lot less variance in the audience reaction with the adult audiences, and that's something I've just found in general the more academic the audience is, and the more academic presentations they see, the less reaction you will ever get from them, good or bad.

Ava and Aiden pointed out how working with youth audiences helped to build their teaching self-efficacy through the need to engage more fully with each audience member. The four interviewees emphasized how the planning and preparation for their teaching experience assisted in developing a feeling of success with their experience. Looking back, Noah explained how he now realized the influence of learning about the ability levels of students as a means of feeling confident in managing the class and making expectations clear.

> **Noah:** It's really challenging. You have to think how to at least have a little bit of idea what their understanding level is so without knowing like even if they don't know what is a gene or genetics or anything. So if I just go and talk in front of them, it's not going to make sense. We develop like in such a way like we started asking them what do plant diseases do? And they're like, "They kill the plants." And what are the effects of plant diseases? They started telling like, "We'll lose the yield." Well, how do you control it? So they would say, "Spray chemicals." Is it good for nature? No. You keep asking questions. And then what are other methods that you know? So they said, "We don't know." So then we said like, "This is what we do as a scientist and which we don't get –" that's the very basic level of teaching people and getting them involved or like going according to the context and we told them, "This is how we make a plant resistant to diseases."

There seemed to be a difference in interviewees feeling confident due to the length of time the graduate students spent engaged with their audiences. Ava, Aiden and William expressed an interest to expand the length of time at the K-12 formal school setting to at least two days, so that the graduate students could see potential cognitive growth and development of K-12 students during and after the lesson they present. All interviewees stated a lack of general cognitive feedback from participants at the non-formal events.

Noah explained he felt minimal value from his experience. In fact, after being prompted by the researcher to describe his experience, he mistakenly described participating in an adult Extension event that was a different event from the description in his non-formal K-12 volunteer reflection essay. Aiden and William expressed the appreciation for skill development from planning the non-formal event (Spring Fest) but were dismayed by the likelihood of a lasting effect upon participants.

> **Aiden:** It's harder to tell if you really did something effective or if because I think the kids are kind of crowded in the Spring Fest, frenzy a little bit and it's kind of hard to separate how enjoyable your activity was or how interesting it was from just the general like extremely elevated level of excitement that the kids are experiencing at Spring Fest already. Yeah, I guess that was really the fast format of it and the general; carnival atmosphere made it a little harder to tell what your effectiveness as a teacher was.

The personal value and importance of previous and this integrated teaching experience to the graduate students was accentuated throughout the interviews. There was a difference between interviewees in regards to overall cost beliefs for outreach with K-12 audiences. William mentioned he was not able to participate in agricultural-based programs in high school due to the college bound focus of students on academic scheduled tracks versus career technical education. The additional travel distance he would need to travel to accommodate an agricultural interest at a different high school was another limiting factor for William. Noah spoke favorably of participating in the formal teaching experience but with the caveat of using the team structure to lessen the overall time requirements.

> **Noah:** You'll lose like a significant amount of time coordinating this and that. You have to have a team. You cannot do it as an individual so you have two or three people at least or three or four people coordinating in so yeah, you'll have four different people and four different work (backgrounds). And like, people who work in different work environments because they'll be having different work pressure so coordinating all of them and getting them to agree for it or like getting them to do their roles, or getting the things done, it's always a big thing. It's a very challenging thing.

The interviewees did not express difficulty with their own academic graduate advisors in regards to participating in the integrated teaching experience, but did recognize the sometimes negative view of outreach or intrusive TA responsibilities within their own plant science disciplines. A unified message for graduate students to be strictly focused on their graduate studies, especially in the first and last years of the program, were described by the interviewees. William and Noah spoke more in regard to Extension-based programing with adults. Ava and Aiden commented on participating in K-12 and TA opportunities as long as their graduate advising committees wouldn't perceive it to be overextending their schedules. Aiden commented on his interest in teaching as a focused element of his academic preparation. Ava nostalgically recalled an initial desire to study for a potential youth education based job with a plant breeding focus.

> **Ava:** Yeah, it was pretty much salary level when I was looking at opportunity -- salary level was one, looking at opportunities after you graduate. So at that time, maybe the program wasn't as developed as it is now and so like youth for education or something like that. I wasn't sure, it wasn't well-defined what my opportunities were going to be as far as job placement. So then, I thought, well if I get a breeding degree then I can go anywhere and do anything, whether it's teaching or whether its Extension or whether it is industry. I could at least have the opportunity to do any of those.

A collective examination of the interviewees provides a few distinguishing features with regard to graduate student personal experiences. While Ava and William referenced working with youth at a young age, William received an extrinsic reward while Ava spoke of continuous personal and social gratification. Noah and Aiden identified graduate schedule constraints as a concern for participating in educational activities beyond the focus of research. However, Aiden recognized the conservation movement within his plant science discipline as perhaps more welcoming for graduate students to seek youth interactions. And although Noah stated he would participate in the program with no incentive, he described a potential lack of support for graduate students to seek out engagement with K-12 audiences.

> **Noah:** The professors would not be happy because like, "Hey, I want to go in, like spend so much time with the kids and teach them like what I'm working on." They would just say "You're wasting time and resources." Even the advisers would not encourage it so it's not an activity that you would readily go ahead and do it unless you are compelled to do it.

4.3.3.3.2 Career readiness summary

The perceived relation of the integrated graduate teaching experiences and preparation of graduate students for their future plant science careers was described with various motivational details by the interviewees. Noah explained how the thought process of simplifying of his research for high school students assisted him in developing an understanding of how to engage with audiences varying from his science field. He described a greater confidence in how he now communicates during non-formal and formal education presentations. An increase in confidence was noted by William.

> **William:** I do think that it's not like…wow, it's an amazing confidence increase. But, I think every time I get in front of an audience like that, yeah. Every time this happens…every time I speak in front of a group of people, that I'm a lot more comfortable talking in front of. So, yeah I do think my confidence was increased for speaking to a K-6 audience like an elementary school audience, yeah.

William further explained the lack of nervousness he has in front of audiences and his increased interest in how peers conduct presentations. He stated how he is more comfortable now when responding to a question he can't answer. While working as a TA he learned the technique of telling the questioning individual, "I'll get back to you on that." He pointed out that it is an easy way to get out of an uncomfortable situation and that it is okay to admit not knowing all the answers.

The graduate students recalled elements of learner-centered teaching instruction. Active learning was identified and described first by all interviewees. Contextual was identified second, but often lacked a fully operational definition in concurrence with the instructional course definition. No interviewee identified the term inquiry learning prior to being prompted in the interview. Inquiry learning was recognized as simply asking questions of the K-12 audience. Interviewees' descriptions of active, inquiry, and contextual learning elements varied and were described in relation to their schema of learning.

> **Ava:** I think all the content was useful. We learned a lot about every person responds differently and they learn differently and some learned through touching, some learned through creativity, some learned through just on they can read a book and take a test over it and they are fine….so that was useful. I think it was very useful to sort of get out of the box. Of what we all know is a classroom. You come in and the teacher has an assignment on the board, you go through the lecture and then we take a quiz at the end of the class. I am a very creative person and I am one of those people who do not do well with like books and tests. So, it was always a challenge for me to just have the just the cut and dry kind of courses, like I am way too creative of a thinker.

Noah referenced active and contextual learning as methods to engage students with hands-on activities and avoid teaching from the chalkboard. Ava and Aiden described LCT elements with reflection upon their personal preferences of learning in comparison and contrast to the methods they used with their K-12 audiences. William and Ava described how they have adapted their current presentation and teaching styles to incorporate elements of LCT. Aiden suggested the program to be expanded to include graduate students in other departments in the college of agriculture.

> **Aiden:** I think the learner-centered teaching is valuable…I mean it's kind of crazy to me that we have a huge body of educators in the form of teaching assistants and even like adjunct post doc faculty teaching classes that have had little or no exposure to educational theory. It's kind of interesting situation and I think that just having a one credit class about learner-centered teaching would help to ameliorate the situation a little bit.

The usefulness of participating in the integrated teaching experiences in regards to career preparation was described by the plant science graduate students with the following varying details: teambuilding, professional development, communication skills, communication techniques, and 21st Century Skills. All interviewees mentioned the unlikelihood of them completing as valuable of a teaching preparation experience as currently exists for graduate TAs in their departments.

> **Aiden:** I would just put it in context that there is really no other way for you to receive training for being a teacher translating your message for a broader audience. There really aren't that many opportunities to do that [outreach teaching] as a graduate student. So [students should] take the ones you could get, and in the grand scheme of things it doesn't take that much of your time.

Noah expressed the usefulness of the teambuilding practice for him as it would mimic the work he would encounter in industry and Extension research. William spoke of a greater appreciation now for the concepts and skills he acquired from the experiences. However, he divides his actions into two distinct categories.

> **William:** I don't think I'm ever going to be an elementary school teacher or a high school teacher, so that would definitely be William [as a] dad territory and William's dad's friends and kids. As a researcher, I mean, Extension and kind of the upper-level science, sure. That's William [as] the researcher…William that won't take no.

William pointed out the professional educational growth and application of concepts by his lab partner for additional outreach projects. William's comments about educational K-12 outreach activities were often phrased as group projects, while Extension-focused projects were identified with self-interest. The present and future useful nature and benefits of practicing communication skills and techniques were evident throughout all the interviews. Ava pointed out skills in communication as the most important element that she identified as essential for all graduate students in future employment settings. Her current employment in industry has helped her see beyond the required plant science knowledge in conjunction with the value of 21st Century Skills.

> **Ava:** I think knowing how to communicate so was great for me. So, the more you practice communicating, it doesn't matter what age group [because] it all lends itself to communication. The more you do that, the better you become at it…and especially when you work in a field like I do it is very technical, the public does not understand what you are talking about. They have very wild(ly) different views on what you do for a living and how you do it, any practice you get breaking things down into a small level, not an uneducated level but just breaking down the science so that its manageable, it's really good for you in your career later on. So it means you can communicate to a wider audience.

The interviewees recognized the balance and negotiation of participating within teaching and professional development opportunities in addition to the traditional coursework. William stated how his advisor was good at determining and encouraging additional developmental activities for the students he encounters.

> **William:** In fact he [my advisor] knows what each one of us is interested in. He's not going to send one of our group members who's interested in academia to a private sector unless it benefits their project. Or vice versa, he might not send me to an additional poster session on campus for academics to get your name and your research out there more when I'm interested in private sector. He is very keenly aware.

William further clarified the reason graduate students in plant sciences don't typically engage with K-12 audiences has been due to "the trajectory a lot of us are on to go into a private sector." He did state his evaluation of the cost belief of attending adult Extension outreach as worthy of his time for travel and engagement. However, he quickly followed up with the interest to visit schools near his potential worksite location. The see-saw responses from William may be a glimpse at the transition he has begun to make towards valuing his actions to increase science literacy among K-12 students. Nevertheless, he supported his decision to do this outreach with the justification of being located within the immediate area of his work assignment.

> **William:** I had to drive to Danville, Indiana to do my Extension talk…like an hour and a half away...ike a Wednesday in the middle of January. Like, whoa, this is awful. I like talking to farmers, but an hour and a half and it is negative two (degrees Fahrenheit)? What am I doing? But it's worth it and I think any mature developing career person who is aspiring to be a plant breeder will realize some of the things that they've done earlier in their life, at the time they hated it but they are better off for doing that. And I think this fits right into that category. In the moment, it might be awful, but it's going to pay more dividends down the end to discuss their research to job interviews to talking to farmers, too. I would love to go back to my high school and help teach if I were in that area. I would offer up, hey, if you want me to come in and talk, let me know.

Throughout the interviews, a sense of interest in helping others understand the advances in plant science research while advancing their career interests was alluded to by each graduate student. The interviewees spoke of their enjoyment for teaching plant science as a communication tool to perhaps debunk the myths the interviewees recognize as deterrents to their careers.

> **Noah:** So they (citizens) know what's going (on) out there, but they don't know the mechanism. So if we can tell them like, "this is what it is doing," that would give an appreciation for what the technology is or how much it takes to develop it…rather than just (saying), "Hey, Monsanto is evil," that's what people say

> Monsanto is evil, but they don't appreciate how much the company has put into – and it's not like I'm not like a pro–Monsanto or anything like that but I'm pro-technology.

Interviewees described the importance of interacting, listening, and then formulating how to engage with their audiences. William noted the need to carefully craft words and messages when you have brief encounters with the public in non-formal educational settings such as Spring Fest or with growers. Likewise, Ava commented on the potential career choice influence of plant science graduate students on K-12 students while visiting K-12 classrooms. The spoken and non-spoken messages of future plant scientists seem to be valued in regards to their career by the interviewees as they approach graduation or have completed a year of work in industry.

4.3.3.3.3 Science literacy summary

The graduate students participating in the interviews described the following various motivations to address challenges with science literacy, including interest, expectancy, attainment value, teaching self-efficacy, and utility. All interviewees reputed a growing change of mentality by established science peers to engage more often with non-science audiences versus strictly academic presentations. William related his interest to reach out to Extension audiences due to his enrollment in land-grant colleges.

> **William:** I think there is equal value for research education and Extension in a land-grant (university). I don't think research is higher than one. I think, well, there are some people that think that and that's just the academic mindset and they are arrogant for it. They need to understand the Extension and education are just as important if not more important to what the researcher's doing. And, yes, I have seen how some people tend to look down on Extension education but they are the small minority. If anything, they are the old guard and they are moving out anyways. So, I think there is a shift to…you have to be able to present your material to a larger audience because we want to have an educated society and I think the push is going to be more towards that. And, you can still be a hard working researcher. You can spend a lot of time making very valuable contributions to science and what you're going to do is you're going to have venues you can continue once you're done. Because you've created networking; once you've been able to establish your research.

The interviewees each mentioned observing an engaging and outreach teaching type of individual during the course of their academic studies. The individuals are described as having well-rounded academic and personal lives, holding special social events to bolster publicity for their research field of study, and the ability to engage with diverse audiences. Graduate students remarked on how they hoped to emulate these qualities in their present or future careers as a way of advancing science literacy. Aiden stated the animosity by extremists toward plant science researchers varies by discipline and is perhaps why he has encountered a widely accepted range of outreach and Extension programs within his discipline.

> **Aiden:** There is nothing sinister about forestry research. Though there were instances…there were plantings of transgenic trees (which) were destroyed by the anti-GMO extremist groups. But, yeah, there isn't the association of forest research with GMOs and the evil corporations in the public mind. The forestry and natural resources field grew out of this…kind of culture of nature loving people who like, teaching people how to identify birds and flowers and stuff. I think there is a strong tradition of engaging with the public and just an expectation that you do that as a researcher. So, in my field I don't see there is a huge division, but I do see a little bit.

The interviewees spoke with confidence when describing their K-12 experiences and the ability to be successful in future tasks due to the lessons learned from the integrated teaching experiences. Noah and Ava mentioned the opportunity for international students to increase their teaching self-efficacy in the United States for science literacy. Noah stated that "there is definitely more outreach and Extension here when compared to [other countries] like India or in any other developing country." By the same token, William stated the need for domestic students to be able to communicate their science to a broader society appears to be the same as for an international student in the program. He felt that some domestic students were as poor at communicating science as some international students.

The interviewees spoke with earnestness for peer graduate students' and colleagues future success with facilitating science literacy. When asked about the role of scientists to society, Ava emphasized the importance of plant breeders to connect with K-12 audiences.

> **Ava:** Big one, probably a bigger one than most of us will admit. For our profession, it wasn't anything before. I mean…we have a job to communicate to the next generation and there has been very little until recently…an emphasis put on those kids in training up like the next generation of scientists. So our plant breeders are pretty scarce and now there has been communication. So some more people are going into it, but there are a lot of breeders in [the United States of] America that are retiring, and there are not a ton [of scientists] to replace them.

Aiden focused his comments more towards identifying and supporting individuals currently in plant sciences. Similar to Ava, Aiden did not believe in forcing individuals into science fields just to fill a quota, but using these types of experiences to help participants feel successful.

> **Aiden:** I think it's really important. I think we have to find a way to encourage people who are in science, but have that motivation to share it with the public. I think we should definitely encourage them to be in positions or give them the opportunity to be in positions that talk to the public.

Furthermore, the usefulness of learning to engage with K-12 audiences was recognized by interviewees as important to the future advancement of science literacy and not be deterred by colleagues with opposing views. Aiden remarked, "how to share scientific knowledge in a way that makes a difference to people who don't spend all their time thinking about science is a good skill." Likewise, William and Ava spoke of an "old guard" that seemingly hid from the public, has gradually begun to move on (retire) with graduate students gravitating more towards the engaging faculty.

4.3.3.4 <u>Engagement-ordered Matrix and Summary</u>

An engagement-ordered matrix was developed to summarize the findings from the interview participants. The matrix provided an in-depth summary of the results to assist in comparing initial perceptions of those selected for the interviews and the actual findings from the study. The results are presented in two parts. Part one (Table 4.13) consists of the summary results from the quantitative data. Part two (Tables 4.14, 4.15, 4.16, and 4.17) consists of the qualitative data divided into four sections, one section for each interview participant. Participants for the interview were selected based upon their ranking on a continuum line between *science in society* and *science for society* in comparison to their classmates in their cohort. Thus, the graduate student from each cohort that most represented the *science in society* view from the collective statements within their essay reflections was chosen (i.e., Ava & Aiden). The same process was repeated to determine the representative for the *science for society* view (i.e., Noah & William)

Table 4.13 Engagement-ordered Matrix Part One

Pseudonym & View	*LCT knowledge difference*	*Self-efficacy [Pre] (M)*	*Self-efficacy [Follow-up] (M)*	*Teaching Rubrics differences*						*Teaching Rubric Total*
				Active	*Inquiry*	*Contextual*	*Plan*	*L & I*	*Environ*	
Noah	+3%	3.75	3.95	+2	+1.25	+1	+2.25	+2.2	+1.5	
(SFS)				(LCT = +4.25)			(Comprehensive = +5.95)			+10.20
Ava	+3%	4.40	4.45	+2.4	+2	+0	+2	+2	+1.25	
(SIS)				(LCT = +4.40)			(Comprehensive = +5.25)			+9.65
William	+3%	3.85	3.75	+1.4	+0.25	+0	+1.5	+1	+0.25	
(SFS)				(LCT = +1.65)			(Comprehensive = +2.75)			+4.40
Aiden	+0%	3.40	4.00	+1.6	+1.25	+0	+1	+0.6	+0.5	
(SIS)				(LCT = +2.85)			(Comprehensive = +2.10)			+4.95

(N = 4)
Note. Science for society - (SFS), Science in society - (SIS)
Self-efficacy: 1= None, 2 = Very little, 3 = Some, 4 = Quite a bit, 5 = Always/A Lot
Teaching rubric: 5-point scale

Table 4.14 Engagement-ordered Matrix - Part Two: Noah (SFS view)

Non-formal experience	*Formal experience*	*Interviews*
TSE: Enhanced my public speaking or interacting skills by talking with farmers and kids EVM: I consider this experience would help me in deciding my future projects to address specific problems and requirements of the farming community. Other graduate students should participate in these kinds of activities to get a personal feel of what farmers require, how to communicate with farmers, attract their attention and get ideas from their real-life problems.	TSE: The students were interested in our class as it was more interactive and had activities which kept them always involved in the class. I learnt to keep the message as simple as possible and straightforward to make it easy for the students to comprehend. EVM: This teaching experience helped us how to use different resources to present the information which would make the teaching process effective. Based on my personal experience, I think these activities helps students to know how to deal with different groups of audience based on their education level and their area of interest.	TSE: I mean like it (courses) made me confident, so like – actually, my research is far advanced than what we teach kids at school. But I have to like simplify so that like they can even understand. So, it made me like to think in a very like where I can make even the normal kids of like 10 – like 10 to 15 years to understand my research. EVM: It's like it's a teambuilding activity, it also mimics like – so it tells you what the main thing is like how to reach out to your audience. This is a very good opportunity that we had; otherwise normally, as a grad student, your major focus would be on going and publishing or like giving your talks even to something more organized or like seminars or conferences, that's where you present your research mostly so to a wider audience or to people who are more in science rather than kids who are 15 or 16 who doesn't know much about science (but) who might end up in science.

Note. Teaching Self-Efficacy Motivation= TSE, Expectancy Value Motivation = EVM.

Table 4.15 Engagement-ordered Matrix - Part Two: Ava (SIS view)

Non-formal experience	*Formal experience*	*Interview*
TSE: I firmly believe that my research comes alive to a student when I am in the room to teach it verses having them read about my research. EVM: I really enjoyed working with these students and encouraging them to try a scientific career. The communication of future graduate students will be a key to increase the attendance of plant breeders in post-secondary education.	TSE: I felt this exercise was applicable to the students' learning and I believe many were making the connection for the first time between their (2nd & 3rd graders) favorite snack and the biology of the plant. EVM: I wanted them to understand why I chose to study plant breeding and plant genetics in college and that they too can study this in college.	TSE: So teaching young kids, I have been teaching classes at church for years. So I am used to those age groups and I like those age groups and I love coming up with creative exercises to learn something. The TA experience with genetics, yes after doing that I felt much more comfortable being more confident that I could do that again (teach undergraduates). EVM: Well like there is no company drive to prove myself to anybody in that way. It's all personal benefits just you are passionate about what you do, you want to teach somebody else something about it, too. We have a job to communicate to the next generation and there has been very little until recently emphasis put on those kids in training up like the next generation of scientists.

Note. Teaching Self-Efficacy Motivation= TSE, Expectancy Value Motivation = EVM.

Table 4.16 Engagement-ordered Matrix - Part Two: William (SFS view)

Non-formal experience	*Formal experience*	*Interview*
TSE: It can be easier to engage a high school senior and discuss issues such as science or knowing where their food comes compared to a younger audience. I did make a common connection with my audience whether they were younger or older. After walking them through what plant created a certain product, I would always tell them "know where your food comes from, it just does not come from a store." EVM: I would have to say good communication skills and being able to relate to as many people as possible were the two most important 'soft skills' that I used to both older and young individuals.	TSE: Challenges during this experience were mostly the classroom dynamics. It can be and was difficult to be the band new people in the classroom and maintaining interest in the lesson itself proved harder than anticipated. EVM: Some of the graduate students, like me, are not involved in K-12 teaching and are more focused on Extension audiences and private sector groups. The experience in the classroom was fun and interesting but not necessarily useful in future careers.	TSE: Looking back what I do remember, I just had the most confidence that he (TA instructor) had prepared me for what we were going to do that day. EVM: I would say, Wow I was really deficient in that. I – if you were to ask me to explain my research in 30 seconds…I would ramble really technically, really scientifically and no one would care at the end of that and now it’s completely different. I hated when the parents got in the way. It’s when their parents would put on the pre-conceived notions; I don’t care about your personal opinion of this but you could do this through a lot of different ways.

Note. Teaching Self-Efficacy Motivation= TSE, Expectancy Value Motivation = EVM.

Table 4.17 Engagement-ordered Matrix - Part Two: Aiden (SIS view)

Non-formal experience	*Formal experience*	*Interview*
TSE: I was uncertain about how comfortably I would be able to communicate with children and their parents, but I don't think I had much trouble. EVM: I made sure to try to connect the plant breeding concepts as closely as I could to things the kids would experience in everyday life. That's why I included wild onion and wild carrot, which are both common weeds, in the activity. Many parents, without provocation, would mention to their kids, "We have that in our yard!"	TSE: I chose urban forestry as the topic of my class for several reasons. I believed the students would connect more strongly with topics they could observe in their own neighborhoods. EVM: I greatly enjoyed the experience of teaching this class. The students (inner-city high school) were a delight and I would do it again any time. This valuable experience certainly confirmed my desire to do teaching/outreach in my future career.	TSE: When we went to Indi(anapolis) to do that teaching experience I mean that was an audience I was totally unfamiliar with. It was. It took a little more mental preparation to get ready for that, than the average presentation. Yeah, well I certainly feel more confident than I did when I started I think the knowledge I gained from the classroom and then from putting it into practice really helped a lot with making me feel like I knew what I was doing a little bit more as a teacher. EVM: There is that kind of mindset, it's just this kind of drudgery that you have to do, to do your more interesting research work and hang out with cool academics at conferences, and I just wish that mindset wasn't as strong because I think, being put in a position to share your knowledge with people who have come to school to learn whether there are as focused as they should be or not, is really an honor and I think it should be seen that way more than as a chore.

Note. Teaching Self-Efficacy Motivation= TSE, Expectancy Value Motivation = EVM.

4.3.3.4.1 Engagement ordered matrix summary

In comparing teaching self-efficacy scores, there was a difference between the individuals in the first cohort (Noah and Ava) and those in the second cohort (William and Aiden). Ava and Aiden were initially perceived to be more likely to have a science in society view. They reported higher post teaching self-efficacy scores (> 4.0) than Noah and William (< 4.0). Additionally, many of their statements within the reflection essays could be recognized as having a science in society view. Ava and Aiden seemingly wanted to build off the general science knowledge that the students in their experiences previously possessed. Whereas, Noah and William presented lessons that contained all the knowledge and skills as an extension of their science expertise.

The most noticeable difference between the cohorts was the results of the analysis with the teaching rubrics. Overall, the first cohort individuals' rubric totals (Noah = +10.20 and Ava = +9.15) reported a greater increase in their abilities across both rubrics than those in the second cohort (William = +4.40 and Aiden = +4.95). When examining the rubrics separately, the first cohort participants had higher rating increases on the comprehensive teaching criteria as compared to the learner-centered teaching criteria. The differences between comprehensive totals for Noah and Ava (Cohort 1) and William and Aiden (Cohort 2) could be reflection of the first cohort not planning the activity for their volunteer experience as compared to those in the second cohort. Thus the first cohort recognized more personal development in the comprehensive skills when completing the rubric immediately following the K-12 formal teaching experience. Ava expressed in her interview that she identified an advancement of her planning and lesson development knowledge and skills. She described these as useful to her planning and lesson development, even though she had developed initial skills from learning experiences for youth individuals prior to the graduate courses.

There were two overarching themes that emerged from the interviews in the matrix summary analysis. The first theme was reflected in the individuals' perception of their teaching self-efficacy. All four interviewees described a continually developing teaching self-efficacy throughout the non-formal and formal education teaching experiences. The graduate students described an initial apprehension of teaching K-12 students in regards to their previous experiences. Ava had prior experience with children the same age as her K-12 audience (i.e., 3rd graders). She noted her apprehension was in reference to her schema of their cognitive abilities with understanding her research topic. Similar to Ava, Noah had apprehensions about explaining complex plant science concepts to K-12 audiences. His apprehensions were different than Ava's due to his lack of experience with teaching any K-12 audiences. And, although Aiden had taught children through Extension outreach activities before, he had not worked with urban students. His apprehension was based upon a concern of being able to engage the K-12 urban audience with a significant learning experience.

The lesson the graduate students facilitated with the K-12 classroom (the formal education experience) of students was the experience they referred to most often when describing their abilities to engage with students. The least mentioned teaching self-efficacy quality would have been abilities related to classroom management. The host K-12 teacher was present in the classroom during the graduate students' teaching experiences, which helped maintain a consistent atmosphere and learning environment for the plant scientist graduate students to teach the K-12 students. When asked if the four interviewees would participate in future teaching experiences, each person's response reflected a confidence in teaching the K-12 audience and expectancy for continued success if given the opportunity.

The second theme was reflected in the individuals' emphasis of elements within expectancy value motivation. All four interviewees described a usefulness or utility value of the non-formal and formal experiences. When asked about the usefulness of the experiences, each interviewee described utility motivation in regards to their career interests. They were describing a possible transfer of how they communicated with K-12 audiences and how this may be a strategy they could use in their future jobs. No individual spoke of a negative or useless concept from the K-12 teaching experience. However, all four graduate students alluded to the unlikely nature of working with K-12 students on a regular basis with their future careers.

Interview participants' comments about their motivation to teach K-12 audiences were divided between intrinsic value and cost beliefs. All interviewees were interested and described an enjoyment in sharing their plant science knowledge with K-12 students, but differed in the justification of their personal involvement in sharing this information as a plant science researcher. Noah and William tended to describe their interest in conjunction with a cost belief, whereas Ava and Aiden seemed to describe interest in relation to a personal importance to share science knowledge and their research with K-12 audiences. Even though Noah and William were initially perceived to predominately reflect a science for society view, the descriptions throughout the interview seemed to show that their motivation to share science was shifting to reflect a science in society view. William seemed to speak much more favorably about his intentions for outreach with K-12 audiences. However, he did still perceived this outreach as a function of his identity within two specific roles (i.e., father figure versus plant breeder). Noah shared that he had no previous interest in teaching K-12 students, but similar to William, was now describing the K-12 teaching experiences as a way to get young scientists interested in plant sciences in post-secondary education. Finally, both Ava and Aiden provide an impression of a certain "duty" of plant breeders to educate non-science audiences, whether it is in the formal role as a professor at a university or as a volunteer through an industry sponsored outreach event. Ava and Aiden seemed to describe a personal responsibility to educate those outside of their current science circles, while William and Noah recognize the importance to share plant science knowledge, but with the reluctance of their own personal investment within and outside their research responsibilities.

CHAPTER 5. CONCLUSIONS & DISCUSSION

5.1 Conclusions and Discussion

There were three conclusions for this study based on the findings from the quantitative and qualitative data. Each conclusion was discussed regarding its interpretation and contribution to the knowledge base. Implications for practice and recommendations for further study were also described.

5.1.1 Conclusion 1: Valued Learning K-12 Engagement using Active Learning

For conclusion one, *plant science graduate students valued learning how to engage with K-12 audiences using active learning*. Although plant science graduate students examined all three components of Learner-Centered Teaching, graduate students shared they used *active learning* strategies when they taught K-12 students more frequently compared to inquiry and contextual learning strategies. Plant science graduate students likely adopted active learning strategies because they were most frequently taught and modeled within the outreach preparatory classes. Active learning strategies lend themselves to helping students develop critical thinking skills about content and as a teaching transition step from a dominant lecture-centered approach (Knobloch & Ball, 2006). This conclusion supported the learner-centered teaching qualities described by Huba and Freed (2000), especially those related to practical learning, teaching role transition, and the roles of active learners. Graduate students' expressed values of the following qualities: (a) how learners can apply knowledge to emerging agricultural issues, (b) how professors (graduate students as teachers) coach and facilitate, intertwining teaching and assessing, and (c) how to engage with learners actively by providing useful and timely feedback. Collectively, active learning practices have been studied within metacognition learning research (Bransford, Brown, & Cocking, 1999). As learners in this study, plant science graduate students' teaching and learning practices reflected the metacognitive focuses of self-assessment, sense-making and reflecting upon the success or changes needed to attain facilitating their specific goals. The graduate students were content specialists in training in the field of plant sciences, and yet they were challenged to translate scientific knowledge and research for a K-12 audience. Perhaps it was the authentic tasks within active learning that enabled them to work comfortably as a novice in a teaching environment, which was different from their other graduate courses.

Furthermore, plant science graduate students described *engaging with K-12 audiences* through hands-on activities, assessing K-12 student feedback, selecting state science standards for their lessons, and asking questions throughout the experience. The observations by plant science graduate students in this study reflected an understanding of the following elements of the active learning process: existing student knowledge, application, feedback, questions, and understanding (Knobloch, 2008). The graduate students' recognition of the dynamic nature of the active learning process was different between the cohorts for the non-formal teaching experiences. In comparing the non-formal experiences, the graduate students in Cohort 2 (i.e., Spring Fest) reflected the elements of the active learning process throughout their descriptions, whereas those in Cohort 1 who merely volunteering at an event, were less descriptive of the elements. Those in Cohort 2 were more invested because the emphasis they placed on the task such that their attainment level was to do more than simply complete the volunteer task. The act of engaging with the participants was more than socially interacting with youth, but an importance to share knowledge and experiences in the learning process. The extension of engaging beyond a simple social encounter aligns with creating a significant learning experience (Fink, 2013). Additionally, graduate students' description of the support and positive outreach modeling by peers and some advisors may be viewed as developing academic values for engaging with K-12 audiences (Nyquist et al., 1999). The graduate students' focus of engaging with the learner in addition to being self-confident in their abilities to teach K-12 students and reflective while adjusting the context to the learner supported the summary of characteristics and dispositions of learner-centered teachers as described by McCombs and Whisler (1997). Several graduate students mentioned the frustration they felt during Spring Fest (i.e., non-formal learning setting) when a participant vocalized a solitary interest in obtaining the attendance token. The graduate students' recognition of the process of learning for the participant beyond the mere accomplishment of constructing an object or attaining an external reward sets a baseline for programs looking to develop graduate students to engage advanced science activities with K-12 audiences.

At the same time, the graduate students were participating in a significant learning experience of their own; *the value of learning to engage*. A taxonomy of significant learning has six distinct categories: "(a) foundational knowledge, (b) application, (c) integration, (d) human dimension, (e) caring, and (f) learning how to learn" (Fink, 2003, pp. 31-32). In this study, graduate students were not only learning the content knowledge of learner-centered teaching, the pedagogical information, but also learning to focus on the quality of the learners' experience when they use LCT methods. The graduate students' descriptions of learning to engage with K-12 students expanded beyond the customary development of knowledge and application for teaching. Graduate students described how they integrated their lessons to help K-12 students connect beyond the classroom and how the concepts of their lessons applied to society. As such, the graduate students described their motivations to make the K-12 learning experiences relate to the everyday lives of their learners. The graduate students were able to hear confirmatory responses by the K-12 students in terms of how the knowledge from the active learning activities fit into their lives (Fink, 2013). Subsequently, through self-reflections graduate students learned about themselves, and often developed personalized meaning about their engagement experiences. During her interview, Ava detailed how she recognized her preferred learning style and why she believed active learning would be beneficial to K-12 students.

> **Ava:** I am a very creative person and I am one of those people who do not do well with like books and tests. So it was always a challenge for me to just have the cut and dry kind of courses, I am way too creative of a thinker and it never interested me and assured little a lot. Even though I had to work really hard for good grades whereas

> somebody else next to me they would be fine, they would cruise right out there. So learner-centered teaching kind of exposes that there are kids that learned differently and it makes more, I guess well-rounded curriculum to grab more students that may be like the 25% in the class might be those students and the 75% maybe they are fine but it kind of encompasses everybody.

Unlike the quick pace of the non-formal experience, the formal K-12 teaching experience provided the graduate students with more time to engage with their audience. Graduate students provided various comments about the development of their lessons utilizing active learning strategies. Graduate students provided various justifications for the activities within their lesson due to identifying the potential challenges of multiple intelligences within their prospective classrooms. Similarly, teachers in training and novice educators are challenged by matching differentiated teaching strategies to diverse classroom learners (Heacox, 2012). Graduate student follow-up interviews helped explain an alignment of the usefulness of Bloom's Taxonomy in reaching the audience via cognitive development of objectives. The self-perception of writing clear objectives with concise verbs may have led the graduate students to a more tangible understanding for creating active learning. Lord and Baviskar (2007) stated the overwhelming use of verbs by teachers which focus on knowledge and comprehension in contrast to the higher cognitive learning verbs that would align with higher order thinking. Thus, graduate students recognized a multi-directional approach to teaching with not only adapting to the breadth of teaching strategies but also engaging the learner's intellectual depth. A few students were noteworthy examples. Within Madison' reflection and threaded throughout the follow-up interviews, there were links of moving beyond the knowledge verbs within lesson objective writing to synthesis and evaluation verbs with regards to potential various multiple intelligences displayed in the classroom. William described how he had recently worked with fellow graduate students also to create active learning plant science curricula for outreach. Michael was one of those students. He used his notes from the outreach courses for illustrating how to write objectives for active learning to those students in the room that had not completed the same preparatory classes.

5.1.2 Conclusion 2: Field-based Teaching Experiences to Practice Communication Skills and Develop Teaching Self-efficacy

For conclusion two, *graduate students described field-based teaching experiences within formal and non-formal educational settings that helped them practice communication skills and develop their teaching self-efficacy*. Authentic opportunities for individuals to practice teaching skills can be achieved through *field-based teaching experiences* (Brush et al., 2003). This study supported the findings by Bredeson (2000) such that field-based teaching experiences have helped teachers connect strategies and knowledge to benefit students' acquisition of new content. Eight out of nine groups of plant science graduate students completed the formal experience within the field-based setting of a traditional K-12 classroom. The locations of the teaching experiences were designed to provide the graduate students with an experience that would be different than if the K-12 audience had visited their laboratory on campus. Due to conflicting academic schedules, one plant science group invited their K-12 students to a university classroom on campus and Jacob was a member of this teaching team. In his reflection of the teaching experience at the university setting, Jacob noted his perception of the experience to likely have been quite different had it been conducted at a K-12 school environment.

> **Jacob:** My experience could have been different, if we had taught in a public school classroom. The class would probably have been larger, and communication may not be as easy.

This along with other reflected comments by plant science graduate students illustrated the value graduate students recognized by participating within a field-based experience. The value and importance of field-based experiences to novice teachers in this study was similar to the responses by a group of students preparing to become agricultural educators (Harlin, Roberts, Dooley, & Murphrey, 2007). Harlin et al. (2007) noted that field-based experiences which placed the students in settings that they would be applying their content knowledge as being influential in the student teachers' learning experience. Likewise, in this study graduate students valued the following elements of a field-based experience: (a) participation in planning the experience, (b) selection of the learners by age and grade level demographics, and (c) multiple visits to teach the selected group of students. The graduate students' reflections noting the contextual setting of a field-based experience supported the relation of Bandura's (1986) triadic interaction of personal factors and behavior with environmental factors as applied to examining field-based settings. Jacob noting the potential difference of the learner-centered teaching experience due to the field-based setting was an example of this influence found within the study. Accordingly, this study adds to the knowledge base that single day field-based experiences may provide a learning experience that is unique and of interest to plant science graduate students with predominately research-oriented career plans (Laursen et al., 2012).

The *nature of the non-formal and formal teaching experiences* varied for the graduate students. Plant science graduate students in the first cohort participated in a non-formal teaching experience (e.g., FFA, 4-H, school science fair) that consisted of observing K-12 students interacting with pre-established activities by the hosting organizations' staff. The experience did not require the graduate students from the first cohort to participate in any planning and minimal implementation of the plans. The roles of the graduate student in the first cohort were to follow the instructions by the sponsoring organization to facilitate a learning activity or interact with the K-12 individuals as a content specialist in training. Even though the plant science graduate students from the first cohort were able to select the volunteer site and activity of their choosing, they expressed a lack of usefulness and personal interest in their volunteer experience in comparison to their peers who engaged in a non-formal learning experience with K-12 students. The plant science graduate students in the second cohort designed and implemented activities for Spring Fest. The graduate students were involved in every stage of the planning and implementation for the outreach exhibits at Spring Fest. The roles of the graduate students in the second cohort included development, construction, implementation, and assessment of the learning experience for visitors at the sponsored tables in the agronomy tent at Spring Fest. It was likely the lack of pre-planning for the non-formal volunteer experience by the first cohort as compared to the in-depth cooperative planning within the second cohort that led to the expressed values. A greater investment or ownership of the project seemed to be recognized by the second cohort of plant science graduate students. These findings were consistent with the literature on individuals volunteering to fulfill a functional approach to satisfy personal motivations (Ryan & Deci, 2000). Individuals express satisfaction and enjoyment from the volunteer experience when they serve in a role that matches their own personal motivations (Clary et al., 1998). The formal teaching experience provided a similar planning and implementation role for all plant science graduate students. Educational activities that place college students in environments outside of the traditional classroom have been noted as providing an enriching educational experience when the activities are more meaningful, develop deeper learning, and generally are self-identified as useful (Kuh, Kinzie, Schuh, & Whitt, 2010). Additionally, the descriptions of personal learning within the plant science graduate students' reflective writings supported previous research statements about the use of reflective writing as an effective learning tool (Clouder, 2000; Matthew, 1998; Pedro, 2006).

The *practicing of communication skills* by plant science graduate students was seemingly intertwined with their development of *teaching self-efficacy*. The graduate students utilized interpersonal skills, more specifically communication skills, to engage with the K-12 students and within teaching teams. Interpersonal skill development has been recognized as a fundamental component of learner-centered teaching experiences (Stephenson, Peritore, Webber, & Kurzynske, 2013). The graduate students in this study described their confidence of teaching tasks in conjunction with communication techniques and skills.

> **Madison:** We missed an opportune time to develop a communicative relationship with the students, and to get them involved from the beginning. We shouldn't have ignored the activity. Instead, we should have started a verbal conversation with them about the differences they saw and what they thought caused the differences.

The development of teaching and communication skills have been recognized as valued outcomes by graduate students and scientists in other outreach education training programs (Andrews et al., 2005; Austin, 2002; McBride et al., 2011). Graduate students self-reported their development of 21st Century Skills, which provided additional support of the K-12 teaching experiences as valuable to the development of graduate students' communication skills (Crawford, Lang, Fink, Dalton, & Fielitz, 2011). The selection of the "quite a bit" and "always a lot" responses on the questionnaire further reflected the 21st Century Skills practiced by graduate students throughout the K-12 teaching experience. The interviews by the four participants provided additional insight as to how practicing communication skills during the course of preparation and implementation contributed to their confidence in teaching. The graduate students alluded to the benefits of instruction for communication through the applied format within the preparatory classes. Aiden stated, "I certainly feel more confident than I did when I started. I think the knowledge I gained from the classroom and then from putting it into practice really helped a lot with making me feel like I knew what I was doing a little bit more as a teacher." Aiden's comment echo's a statement by Tschannen-Moran and Hoy (2001) in regards to the novice teacher moving from the vicarious experiences in the university classrooms to the practical application and learning within the mastery experiences within the classroom. Early in William's interview, he spoke of his strengths in public speaking and later clarified that a role model of his in non-formal education was more than just a good speaker. His role model was able to capture the audience through engaging with the audience. William had observed this person at different venues with varying audiences and spoke of a desire to be able to communicate with his future audiences the way that his role model demonstrated an authentic connection. This personal confidence in performing a specific act, in this case teaching, is aligned with the self-perceived capabilities in a teaching environment as defined within teaching self-efficacy by Tschannen-Moran and Hoy (2007). The plant science graduate students distinguished two focal points within their teaching self-efficacy development. The follow-up questionnaire reported more individuals identifying their perceived abilities to "bring real-life experiences to the classroom" and "adjusting their teaching to accommodate different learning styles of students." The follow-up interviews collectively exhibited the perception of a developing mastery to engage with K-12 audiences. As graduate students shared examples of problems facing plant breeders in society, it is likely they were describing real-life scenarios. These active life-based lessons provided the opportunities for the graduate students' personal mastery to grow in response to the positive feedback from the K-12 audience. The graduate students who adjusted their lessons according to the needs of the learners reflected the reciprocal nature of Bandura (1986) psychological model. As such, graduate students participating within these types of teaching experiences may have been more efficacious to assume teaching responsibilities in higher education, industry or government positions. Additionally, graduate students working within teaching groups may have contributed to collective teaching self-efficacy (Fives & Looney, 2009).

5.1.3 Conclusion 3: Enjoyment and Usefulness to Communicate Science

For conclusion three, *plant science graduate students described an enjoyment of teaching K-12 audiences and the K-12 experience was useful in preparing them to communicate science to technical and non-technical audiences*. The utility and enjoyment described by plant science graduate students suggests the integrated K-12 engagement training experience fulfilled their need for autonomy. Graduate students' reflections of enjoyment were referenced with recognition to the sense of control that the graduate students achieved throughout their learning experiences. Because the integrated K-12 engagement training experiences was learner-centered, graduate students were able to mold their own learning experiences by making choices regarding the content, teaching strategy, and targeted audience of their K-12 lessons. As such, graduate students described the enjoyment of the K-12 engagement experience because it activated a sense of agency or autonomy (Deci & Ryan, 2012) versus simply having fun.

Graduate students' *enjoyment* of participating in the K-12 teaching experiences was summarized into three major points: (a) an innate joy of sharing a personal passion for plants with others in society, (b) the choice in selecting the topic and the activity, and (c) the choice in selecting the grade level for the formal teaching experience. A majority of plant science graduate students expressed comments of enjoyment within their non-formal reflection in regards to interacting with a K-12 audience. The enjoyment expressed within many of the non-formal reflections were direct statements such as: "I really enjoyed this experience." An elaboration of the enjoyment quality was often found more so in the formal teaching experiences and the follow-up interviews. The formal teaching reflections and the follow-up interviews provided descriptive criteria for why the experiences were enjoyed. Hence, enjoyment was the most expressed motivational construct within this study. The findings from this study were consistent with the intent of individuals to persist in an activity due to high interest and desire to be engaged in the activity regardless of a single outcome (Eccles & Wigfield, 2002). The difference in statements of enjoyment by participants within the non-formal and formal teaching experiences may be due to the differences in individual and situational interest (Renninger, Hidi, & Krapp, 2014). In the follow-up interviews, graduate students were asked about the pros and cons of the two K-12 engagement experiences. In comparison, graduate students shared more benefits regarding the formal teaching experience. Moreover, graduate students spent more time sharing examples from the formal experience versus the non-formal teaching experience. Graduate students in the integrated K-12 engagement training experience unknowingly referenced the transferable skill development from using backward design to build their lessons. The interviewees remarked how they adjusted the choices and actions they made as teaching assistants in college courses upon completion of their K-12 teaching experiences. The recognition of adjusting the actions the graduate students previously performed with K-12 audiences to actions suitable for college teaching could be described as a transfer of learning (Leberman, McDonald, & Doyle, 2006). Likewise, the transfer of learning capability has been recognized as essential for individuals who may encounter working across teams in industry (Donovan, Hannigan, & Crowe, 2001).

The two elements (i.e., feeling and value) of individual interest as described by Schiefele (1991) perhaps further distinguished the difference between the graduate students' interest in the non-formal and formal teaching experiences. A "felt good" description seems to encapsulate a general summary of the non-formal experience for those in Cohort 1 with minimal planning in comparison to the value added feeling from the non-formal experience for Cohort 2 and both groups formal teaching experience. The formal teaching experience enabled graduate students the opportunity to select the topic and develop activities to reflect personal interests within their lessons. Graduate students described the usefulness of teaching a topic they were studying and the planning process in greater detail within the formal reflections and interviews. It is likely the graduate students related the reflection of knowledge and practice of planning to their future career tasks (E. A. Ruona, Leimbach, F. Holton Iii, & Bates, 2002). The graduate students' descriptions of relating these experiences to their career development were consistent with outreach findings for career building (Laursen et al., 2007), self-guided reflection development (Austin, 2002), and retaining academic rigor (Koshland, 1994) Whereas, the non-formal volunteer teaching experience for Cohort 1 was simply an outreach event they participated within, which is representative of situational interest (Wigfield & Eccles, 1992). The graduate students in Cohort 2 distinguished a deeper value of the non-formal experience due to their more extensive involvement and decision-making process throughout the entire non-formal experience. The reflections on the actual teaching events in retrospect to their previous experiences were attributions for their interpretative process (Schunk et al., 2008). Likewise, plant science graduate students appreciated the option of selecting the age group or grade level for their formal teaching location as it helped facilitate a positive experience. The selection of the age group may have enabled graduate students to feel a sense of control of the environment and thus develop a level of comfort in the environment (Deci & Ryan, 2012; Schunk & Pajares, 2009). Accordingly, the graduate students may have recognized or preconceived their abilities to do well with a particular age group or the perceived ability to influence a particular age group.

There were several reasons why graduate students enjoyed this experience whereas other budding scientists may find this type of experience as trivial and distracting to their graduate studies. The plant science graduate students' expressions of enjoyment were typically followed up by the recognition of *usefulness* of the K-12 teaching experience to the graduate students. Although there was a general consensus of the enjoyment with engaging lessons to extend their plant science knowledge to the K-12 audience, plant science graduate students distinguished a number of utility beliefs or reasons as to why the tasks were useful. These beliefs often reflected the values graduate students identified under a generally known skillset of communication skills. The described differences between their beliefs in the utility of the experience and the personal reasons for participating reflected the task value research by Eccles and Wigfield (2002). The graduate students' initial interest may have been only in response to the requirement to complete the course. Graduate students described how their developing communication skills could be used in their future career roles (Crawford et al., 2011). Moreover, graduate students recognized the transferability of the communication skills to different audiences, such as adults at an Extension field day, but also noted that their abilities to engage with a particular audience were still unknown. The fundamentals of the communication skills could be present in their minds, but were still malleable in terms of the environmental conditions presented by the audience. A notable divide was between the two ends of the "science in and for society" spectrum of views, those audiences that are knowledgeable of current technological innovations in comparison to those that are not.

In the final analysis, the graduate students' descriptions and alluded actions provide a glimpse into the motivation of plant science graduate students' preparation to *communicate science to technical and non-technical audiences*. The self-perceptions by the graduate students within their reflection essays and the discussion highlights from the interviews illustrate the blurring of the line between the two camps or ideologies "science in society" and "science for society." Mogendorff et al. (2012) alluded two contrasting ideologies with respect to communication dependent upon the setting. One ideology focusing on scientists being more equipped to evaluate scientific knowledge than the common person (i.e., transmission), while the other recognizes the capability of the audience to contain informed stakeholders, but only when it was a scientific-oriented audience (i.e., engagement).

In the case of outreach education, scientists may view the K-12 audiences as lacking the competence to understand complex science. The challenge for graduate programs may be the identification of the individuals who fall into the "science for society" view, who are not as likely to support outreach to non-technical audiences such as K-12. It can be challenging as graduate students, who seem to embody and write effectively about outreach experiences, may simply go through the motions, but not truly gain an understanding of communicating for science literacy. For example, within the follow-up interview, Noah described a desire for individuals to understand science, but stopped short of how his engagement with others could help them to learn. He was more focused on simply telling them the answers to questions versus the development of an engaging discussion to promote science inquiry. The graduate students who seemed to exhibit the science in society tendencies through the written reflections spoke as a person who was moving away from that focus during follow-up interviews. In his reflections, William exhibited all the typical tendencies of a scientist who believes that he has a superior authority of knowledge and his understanding of how to apply or whether to interact with a non-scientist is socially acceptable. His previous encounters with teaching were strictly for what he could provide to the audience and how he judged his abilities to accomplish the task.

Subsequently within the follow-up interview, William spoke unknowingly of a developing constructivist nature from his teaching experiences. Although he still retained his high regard for his intellectual capacity, he had started to distinguish how the "old guard" of plant breeders had missed the opportunity to not only inform society, but to facilitate an understanding of plant sciences as applied through the inquiry of the audience members. William did, however, distinguish his future work with the K-12 audience as a feature of his future personal lifestyle as a fatherly figure and how his scientist knowledge would more so be a feature of Extension work with adults. Noah's division of engaging in Extension and K-12 outreach were quite separate with the K-12 group as an unlikely audience for further invested interest in gaining experience. Graduate students who reflected the "science for society" view seemed to split the beliefs and values into two categories that did not coincide when speaking to a particular audience. These graduate students described a division of career or work utility and interest according to the age and purpose of the engagement with those outside of their science circles. Interestingly enough, after completing the course, these individuals may exhibit some of the characteristics of the "science for society" but identify themselves as "science in society." The findings of this study provided some evidence as to the development of graduate students and their self-perceived abilities to extend science knowledge to varying audiences as suggested within Leshner (2007) and McBride et al. (2011).

Graduate students may have evaluated the utility of the experience in comparison to cost beliefs encountered when determining the personal value of the integrated K-12 engagement training experience. Graduate students described the utility of the experience with different future goals. However, the narratives seemed to allude to those describing cost beliefs to be leaning more towards a science for society view. The thought that cost beliefs would be the determining factor as to which graduate students fell into the science for society view was unfounded. There were no plant science graduate students who stated a lack of enjoyment due to a cost belief. Graduate students who initially exhibited "science for society" values and beliefs seemed to lean strongly toward working with adult audiences due to career interests. However, graduate students were not hesitant to point out numerous reasons why scientists should communicate with all types of audiences. When graduate students could link educating a non-technical audience to their career interests, the interest to share plant science knowledge was emphasized by graduate students' lengthy descriptions in the reflections and follow-up interviews. These graduate students seem to be describing a situational interest (Eccles & Wigfield, 2002) in regards to a "science for society" view of outreach. More importantly, the facilitation of these outreach teaching experiences can provide a positive experience, even if the experiences may need to be introduced as situational interest initially, and thus potentially building the necessary foundation for the graduate student to likely participate in future outreach teaching opportunities.

5.2 Implications for Practice and Policy

As graduate-level academic programs continue to adjust and adapt to prepare plant science graduate students to meet the needs of an ever changing in society, the following implications are suggestions for (a) instructional preparation, (b) participation in contextual settings, and (c) constructivist approach to learning to facilitate science outreach.

5.2.1 Instructional Preparation

Teaching programs specific to facilitating graduate students' understanding and application of outreach teaching are continuously adapting to prepare graduate students to meet future societal pressures (McBride et al., 2011). The results of this study indicated an opportunity for instructors of graduate students with non-pedagogical backgrounds to adjust their coursework to include various learning processes. The adoption of learning some educational theory as applied through outreach education practice provided the graduate student with skills to cultivate their novice instructional skills. Some promising educational strategy examples from this study included: learner-centered teaching, Bloom's taxonomy, and multiple intelligences. The strategies within these theories have been recognized as encompassing engaging teaching styles to customize the learning for the learner (Reigeluth & Moore, 1999). Additionally, an adaptation of the semester-long course into active learning seminars and professional development workshops may provide pedagogical strategies for post docs and novice university faculty who might value engaging in active learning with students within their courses. Later on, these graduate students, post docs, and professors who recognize the elements of the active learning process may be able to design future engaging activities with advanced science content for youth educational organizations such as 4-H, FFA, Future Career and Community Leaders of America, Girl Scouts of America, and Boy Scouts of America.

Additionally, graduate students indirectly experienced the opportunity to craft science literacy messages with a positive proactive focus versus the often industry reactive actions to poorly misinformed publicity from a public media source (Gregory & Miller, 2000; Marris, 2001). Graduate students linked the need for their research to societal challenges. The challenge to feed an increasing world population (Godfray et al., 2010), adapting plants to thrive among changing environmental conditions (Tester & Langridge, 2010), and developing plants to minimize previously poor farming practices, (Lichtfouse et al., 2009) were just a few of focal points for these graduate student developed lessons. For example, Abigail and Madison chose to present their K-12 classroom of students with current societal challenges in conjunction the facts of how

GMOs are currently developed. The K-12 students were given the intellectual tools to make fact-based decisions throughout the learning experience versus a single message of "GMOs are not evil." Similarly, Pajares (2001) determined that positive psychological variables were related to achievement goals and expectancy beliefs and values.

5.2.2 Participation in Contextual Settings

Graduate programs of study across various disciplines place their graduate students in contextual settings to facilitate learning (Crone et al., 2011; Gardner & Jones, 2011; Jasensky & Ewing, 2008). Preparing graduate students for science literacy outreach should also continually adapt to provide graduate students with a variety of field-based settings. In this study, graduate students described differences with the shortened time engagement for outreach in the non-formal setting of Spring Fest in comparison to the classroom teaching experience. Time was a key element the graduate students described as different in developing (i.e., planning) and exhibiting (i.e., teaching) their science messages within the non-formal and formal settings. The graduate students' recognition of timing within a learning experience reflects the structure and pacing of instruction as described by Danielson (2007). The graduate students described the sense of accomplishment when the time allotment (i.e., approximately 40 hours) permitted the graduate student to determine if their science messages were learned or positively received by the K-12 students. The graduate students noted the verbal and non-verbal feedback by students in either setting to be more obvious and easier to recognize as compared to their TA experiences at the university. Additionally, an immediacy of the verbal and non-verbal feedback as described by Frymier and Houser (2000) was important in shaping the graduate students' experience.

These settings may also be more productive for the learning experience, if the graduate students' preferences for characteristics within the field-based experiences could be discussed and evaluated with a course instructor. By participating within the discussion, the course instructor may help the student to develop autonomy in the learning setting (Whitelock, Faulkner, & Miell, 2008). The development of continued interest by graduate students may have been due to providing positive initial experiences. The graduate students were prepared with content (i.e., LCT knowledge) and strategies to facilitate the lesson and were then placed in a setting that could promote autonomy in a teaching context. Ryan and Deci (2000) state that autonomy and competence assist in the development of intrinsic motivation. Additionally, the motivation of plant science graduate students to translate science to technical and non-technical audiences was described with different values in this study and could have been driven by the beliefs initially developed within the personal graduate experience. Further, assisting graduate students in examining their communication skills within field-based settings should require the graduate students to plan and conduct K-12 teaching experiences to support their developing teaching self-efficacy. The personal examination and reflection upon these mastery experiences may assist the graduate student in developing an associated teaching self-efficacy with the teaching task with a K-12 audience. These findings were consistent with those of beginning agricultural education teachers developing teaching self-efficacy in the classroom along with positive indications to continue in the teaching field (Wolf, 2011).

5.2.3 Constructivist Approach to Learning to Facilitate Science Outreach

Graduate programs of study should provide focus on the individually constructed meaning graduate students develop as they acquire new knowledge and skills (Jean-Marie, Normore, & Palgrave, 2010). Plant science graduate students within this study were receptive to utilizing learner-centered teaching strategies to engage with K-12 audiences. Graduate students were not only taught learner-centered teaching strategies, but they also observed the course instructors model learner-centered teaching throughout the duration of the two courses of instruction. Plant science graduate programs of study may benefit by adding active learning coursework to assist in graduate students' pedagogical development. Coursework for graduate students should include opportunities to design and implement learning experiences for K-12 audiences. As recognized in other studies, graduate students reflect the instructional strategies of their mentors and those they observe in the university settings (Austin, 2002; Kearney, 2013). Thus, it would also be beneficial for graduate students to participate in classes that are instructed using learner-centered teaching strategies.

Through the K-12 experience, the plant science graduate students may be able to learn to translate their science to a variety of colleagues in the future workplace, such as across academic disciplines at universities, private industry, and government. Plant science graduate students may be able to communicate more effectively to the diverse undergraduate body of students they may face at a land-grant university. Additionally, graduate students at land-grant universities may have an advantage to assist in securing funding as grant applications continue to require educational components. These educational components would be aligned with the required the Broader Impacts criterion (Nadkarni & Stasch, 2013). With industry in mind, the plant science graduate students may exhibit more confidence in communicating with human resource officers for future job interviews or explaining their science to media outlets.

5.2.4 Implications for Policy

Although the design of the study precluded assumptions of causality, plant science graduate students described the development and practice of 21st Century Skills. The evidence from numerous data points within the study further illustrated how the graduate students transferred these skills not only between assignments for the outreach courses but also infused the skills into their graduate and professional careers. Graduate students were continually relating and translating their understanding of how plant science research could be integrated within the dynamic setting of the grant project focusing the graduate students' interest in industry, academics and Extension. It was evident that graduate students saw the critical nature of educating the public through outreach opportunities even though some of the students may have struggled with crafting initial age appropriate lessons.

The graduate students in this study described similar development of communication and instructional skills as noted in the Mitchell et al. (2003) review of

NSF graduate teaching fellows programs, but graduate students in this study extended their descriptions to progress beyond the mere dissemination of science knowledge and thus created engaging learning experiences for their K-12 audiences. Additionally, plant science graduate students reflected a complementary blending of educational outreach experiences in accordance with research responsibilities. The cohesive nature within the experience could have been due to the graduate students' reflections of a majority of advisors and mentors expressing positive outreach messages and career modeling. The findings of this study further support the continual need for higher education research programs to offer instructional outreach experiences for graduate students as previously encouraged by Brownell et al. (2013). Further, the instructional courses and experiences within this study reflected the opportunity and success of graduate students' transferring strategies across learning experiences through experiential learning as emphasized by Whitmer et al. (2010).

5.3 Recommendations for Further Study

Limitations of the study provided the basis for future research opportunities. Moreover, educational researchers seek to find alternative methods and plausible reasons to extend research beyond the specific demographics of the current study was the driving force behind the development of these recommendations for further applied motivation theory based research.

5.3.1 Research Methodology

The mixed methods of this study attempted to describe the motivations of the graduate students through the lens of two compatible motivation theories. Autonomy and goal-orientation were motivational elements that were acknowledged by the researcher but not the main focus of this study. An examination of plant science graduate students' training to facilitate outreach activities with K-12 audiences as viewed through different theoretical frameworks may provide additional understanding of the graduate students' motivation for science literacy. As this study followed a deductive approach with a defined theoretical framework, it is likely a heuristic grounded theory may provide greater insight into the constructed view of outreach education by graduate plant scientists. Further research should continue to expand upon the quantitative responses in general teaching self-efficacy questionnaires to elicit short answer responses for deeper reflection of the perceptions by the participants. The interviews from this study provided more context, specific details, and clarification of the graduate students' motivation. The value of qualitative methodological questions may provide graduate programs with elaborated factors of motivational interest. Likewise, the analysis between interview data and written response data has been recognized as providing a researcher with varied views of the focused study content. Depending upon the environment of how the data is acquired, it may be more or less naturally occurring and should be recognized accordingly (Perakyla & Ruusuvuori, 2011). The extended elapse of time between the last student completing the teaching experience and the follow-up interviews (i.e., 16 months) could have permitted the interviewed participants in this study additional time to experience additional educational activities that may have influenced their motivation to share plant science with K-12 audiences. As such, this may be why individuals initially selected from each cohort as representatives of the end of the continuum for "science in" and "science for" were describing adjusted views during the interview session.

5.3.2 Demographics of Participants

There were a small number of participants within this study due to the limited number of graduate students in the program sponsored by the AFRI grant. As this study was conducted with a small sample of graduate students within a single discipline (i.e., plant sciences), a larger sample of participants from various disciplines and a diverse population may provide greater insight into the influence of context and cultural views. First, the graduate students in this study provided a few comments about growing up in rural or urban settings. Graduate students in the interview sessions compared their rural or urban childhood to that of their K-12 students' environments. These differences in childhood environments may have added a unique feeling by the graduate students in a different school classroom environment. Additionally, gender, graduate student as a parent status, and ethnic culture of the domestic student may be a potential variable to examine in further detail in future studies. Secondly, this study contained a small number of international students; it might be of additional interest to examine the outreach of international graduate students as applied to their home countries. Moreover, international students may also have childhood and cultural differences in addition to their international status that may have influenced their reflection of the experience. International students recognized the barriers to perform outreach by scientists to K-12 audiences in other countries due to cultural differences. Replicating the study in a country with very minimal outreach education may provide awareness of science literacy challenges within that country.

There may have been a unique acceptance of outreach education within plant science disciplines, thus branching out to study other agricultural disciplines such as: animal sciences, food science, agricultural and biological engineering may provide different results. This notion of branching out to other disciplines within the context of agriculture aligns with findings by Menges and Austin (2001) in that a discipline and institutional structure may be unique to the learning experience. The current study had a minimal number of participants working towards obtaining their masters' degree in comparison to doctoral seeking degree participants. Future studies should examine if degree of focus is a factor in the expectancy value motivation of graduate students to teach science through outreach to K-12 audiences.

5.3.3 Program Instruction

The learner-centered teaching instruction and presented strategies in the courses for this study were predominately focused on active learning. Furthermore, the graduate students predominate identification of active learning strategies and limited use of inquiry strategies may also be a reflection of the "bumpy road" as described by Felder and Brent (1996). Although the graduate students did not express a bumpy road experience, this transition from teacher-centered inquiry to student-centered inquiry may have been difficult for graduate students to identify the less tangible assessments associated with inquiry learning. Graduate students may have distinguished the simple teacher-directed questioning of K-12 students as inquiry but not self-identified the student developed analytical skills, critical thinking, information processing, and problem-solving skills as typified in inquiry learning. Further studies should investigate if increased strategies for inquiry and contextual learning yield greater adoption of inquiry and contextual teaching methods.

Plant science graduate students in this study self-reported supportive academic advisors throughout the project and received graduate funding through enrollment in the grant. And while this study did determine all interviewees had different academic advisors, this study did not expand to include the role of the graduate student advisor in the analysis. Researchers may want to examine the role of the advisor and mentoring in preparing graduate students to engage with K-12 audiences. Additionally, funding continues to be limited for extensive and inclusive GK-12 training programs. Further research should continue to examine how adapted programs such as this one compare to the extensive and inclusive GK-12 training programs. Likewise, it would be of value to survey the K-12 students to determine their perception of the graduate student’s teaching abilities and knowledge gained with this condensed teaching preparation.

Because experiences were described with varying levels of intensity and focus on the learning outcomes, an examination of how graduate students prepared themselves to respond differently toward experiences might lend to preparing others given a list of typical environmental settings. The environmental settings might include average length of time speaking to an individual at the event or demographics of the potential audience. William commented on his enjoyment of the Spring Fest activities because his experience was similar to that of his previous non-formal learning experiences in Extension settings with adults. Additionally, research should examine urban audience versus rural audience placement settings, and how graduate students’ experience with prior familiarity in that setting affect the graduate students’ development of teaching self-efficacy.

5.3.4 Motivation for Science Literacy

Further research should be conducted to help plant science graduate students learn to critically analyze public messages on the negatively perceived controversial strategies for plant breeding that is acceptable in certain plant disciplines and not in others. For example, plant breeding efforts to save the American chestnut are seemingly welcomed science research in the view of forestry conservation. Whereas the plant breeding of genetically modified soybeans to resist plant disease is considered part of a dangerous agricultural research agenda (Wald, 2013).

Graduate students commented on role models and advisors who supported outreach education for the advancement of science literacy. These working scientists demonstrated work and career balance in addition to an attention of societal concerns in the field of plant sciences. With continued emphasis on interdisciplinary work with academic teams, future studies may delve deeper into the influence of multiple role models and mentors and if there is an ideal number of mentors to acquire. Additionally, life science graduate students often work within lab groups. Further research should examine the influence of the peers and mentors on graduate students and their decisions to participate in outreach for science literacy. Kong et al. (2013) determined numerous influences on graduate students by interactions with peers, advisors and administrative personnel throughout their graduate programs. Lastly, it would be of interest to examine those who engage in learning about applied educational theories and how or if this influences their lab partners. Graduate students in lab settings are often working in what are termed communities of learners. Zhao and Kuh (2004) described these peer settings as having positive influences on some participants and potentially challenging to others. Graduates in this study were provided the option of selecting their teammates for the teaching experiences. Perhaps different reflections may occur if students were placed into teams similar to industry team assignments.

5.4 Research Summary

In summary, this mixed methods study described the outreach teaching beliefs and values of plant science graduate students after participating in an integrated graduate student training experience. The research study was conceptualized into three phases of a multistrand design and resulted in three major conclusions. First, plant science graduate students valued learning how to engage with K-12 audiences using active learning. Graduate students described acquiring and practicing learner-centered teaching strategies to teach K-12 audiences of which active learning was most utilized. The engaging actions of the graduate students facilitated a significant personal learning experience beyond that of simply sharing knowledge. Second, graduate students described field-based teaching experiences within formal and non-formal educational settings that helped them practice communication skills and develop their teaching self-efficacy. The plant science graduate students described the non-formal and formal teaching experiences with varying teaching beliefs and values. And third, graduate students described an enjoyment of teaching K-12 audiences and the K-12 experience was useful in preparing them to communicate science to technical and non-technical audiences. The usefulness and enjoyment of the integrated learning experiences were described in conjunction with graduate students' ability to develop autonomy throughout the experience.

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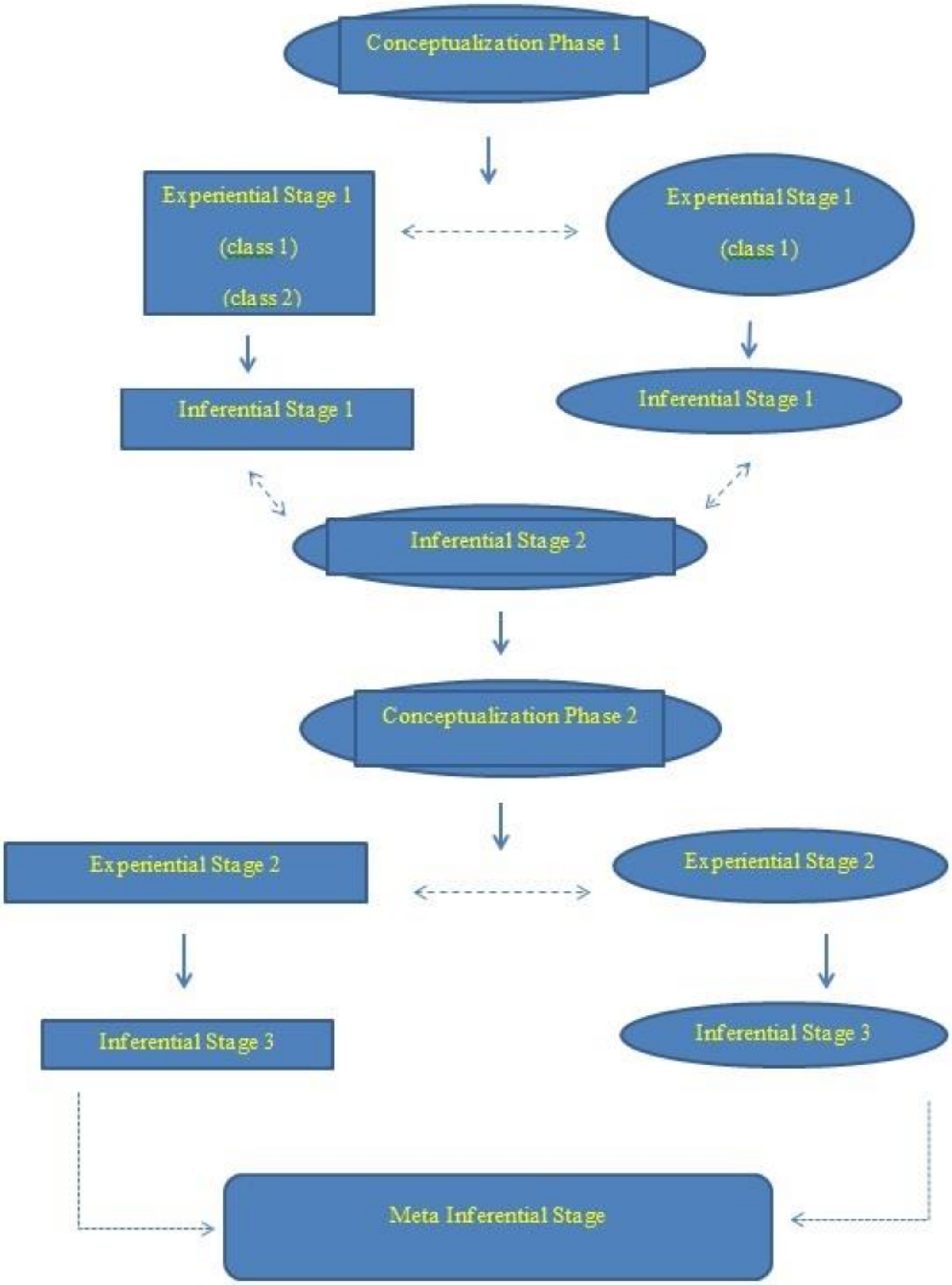
APPENDICES

Appendix A Sequential Mixed Methods Research Design



Sequential Mixed Methods Research Design

Appendix B IRB Study Approval

PURDUE UNIVERSITY

HUMAN RESEARCH PROTECTION PROGRAM
INSTITUTIONAL REVIEW BOARDS

To:	NEIL KNOBLOCH AGAD
From:	JEANNIE DICLEMENTI, Chair Social Science IRB
Date:	05/12/2014
Committee Action:	**Renewal**
IRB Action Date	05/09/2014
IRB Protocol #	1301013139
Study Title	Examining Plant Scientists Experiences, Beliefs and Values after Teaching a K-12 Audience
Expiration Date	05/08/2015

Following review by the Institutional Review Board (IRB), the above-referenced protocol has been approved. This approval permits you to recruit subjects up to the number indicated on the application form and to conduct the research as it is approved. The IRB-stamped and dated consent, assent, and/or information form(s) approved for this protocol are enclosed. Please make copies from these document(s) both for subjects to sign should they choose to enroll in your study and for subjects to keep for their records. Information forms should not be signed. Researchers should keep all consent/assent forms for a period no less than three (3) years following closure of the protocol.

Revisions/Amendments: If you wish to change any aspect of this study, please submit the requested changes to the IRB using the appropriate form. IRB approval must be obtained before implementing any changes unless the change is to remove an immediate hazard to subjects in which case the IRB should be immediately informed following the change.

Continuing Review: It is the Principal Investigator's responsibility to obtain continuing review and approval for this protocol prior to the expiration date noted above. Please allow sufficient time for continued review and approval. No research activity of any sort may continue beyond the expiration date. Failure to receive approval for continuation before the expiration date will result in the approval's expiration on the expiration date. Data collected following the expiration date is unapproved research and cannot be used for research purposes including reporting or publishing as research data.

Unanticipated Problems/Adverse Events: Researchers must report unanticipated problems and/or adverse events to the IRB. If the problem/adverse event is serious, or is expected but occurs with unexpected severity or frequency, or the problem/even is unanticipated, it must be reported to the IRB within 48 hours of learning of the event and a written report submitted within five (5) business days. All other problems/events should be reported at the time of Continuing Review.

We wish you good luck with your work. Please retain copy of this letter for your records.

Ernest C. Young Hall, 10th Floor - 155 S. Grant St. - West Lafayette, IN 47907-2114 - (765) 494-5942 - Fax: (765) 494-9911

Appendix C IRB Amendment Approval

PURDUE
UNIVERSITY

HUMAN RESEARCH PROTECTION PROGRAM
INSTITUTIONAL REVIEW BOARDS

To:	NEIL KNOBLOCH AGAD
From:	JEANNIE DICLEMENTI, Chair Social Science IRB
Date:	09/03/2014
Committee Action:	**Amendment to Approved Protocol**
IRB Action Date	09/03/2014
IRB Protocol #	1301013139
Study Title	Examining Plant Scientists Experiences, Beliefs and Values after Teaching a K-12 Audience
Expiration Date	05/08/2015

Following review by the Institutional Review Board (IRB), the above-referenced protocol has been approved. This approval permits you to recruit subjects up to the number indicated on the application form and to conduct the research as it is approved. The IRB-stamped and dated consent, assent, and/or information form(s) approved for this protocol are enclosed. Please make copies from these document(s) both for subjects to sign should they choose to enroll in your study and for subjects to keep for their records. Information forms should not be signed. Researchers should keep all consent/assent forms for a period no less than three (3) years following closure of the protocol.

Revisions/Amendments: If you wish to change any aspect of this study, please submit the requested changes to the IRB using the appropriate form. IRB approval must be obtained before implementing any changes unless the change is to remove an immediate hazard to subjects in which case the IRB should be immediately informed following the change.

Continuing Review: It is the Principal Investigator's responsibility to obtain continuing review and approval for this protocol prior to the expiration date noted above. Please allow sufficient time for continued review and approval. No research activity of any sort may continue beyond the expiration date. Failure to receive approval for continuation before the expiration date will result in the approval's expiration on the expiration date. Data collected following the expiration date is unapproved research and cannot be used for research purposes including reporting or publishing as research data.

Unanticipated Problems/Adverse Events: Researchers must report unanticipated problems and/or adverse events to the IRB. If the problem/adverse event is serious, or is expected but occurs with unexpected severity or frequency, or the problem/even is unanticipated, it must be reported to the IRB within 48 hours of learning of the event and a written report submitted within five (5) business days. All other problems/events should be reported at the time of Continuing Review.

We wish you good luck with your work. Please retain copy of this letter for your records.

Appendix D Follow-up Study Invitation Letter

Greetings ___________________,

I hope this letter finds you enjoying the remaining days of summer and preparing for the fall harvest season. I am completing the final data collection of my dissertation and would like your input on a few follow-up questions about your thoughts with the K-12 teaching experiences as part of the AFRI project. The follow-up questionnaire link is listed below and should take no more than 10 minutes to complete. I will also need for you to sign the attached Purdue IRB participant consent form and then scan and send that to me by email, fax or campus mail. I have listed the contact information at the end of this email. As a token of appreciation, I will send you a $5 gift card to Starbucks.

Moreover, I will be contacting a few of you to participate in a follow-up interview. Through the interview, I hope to gain a more detailed understanding of your K-12 experience and your views on science literacy. At the conclusion of the interview, you will receive a $25 VISA gift card as a thank-you for the valuable hour of your time. I have truly enjoyed working with you through the activities of the AFRI project and hope that you are able to spare some time to share your learning experiences with me.

To complete the questionnaire, click here –
https://purdue.qualtrics.com/SE/?SID=SV_5vdWL2GfRyKWTEp

I would be very grateful if you complete the questionnaire by September 12, 2014.

Fax: 765.496.1152
Email: welsh2@purdue.edu
Campus mail: 221 Ag Admin Building c/o Melissa Welsh

Thank-you in advance for your assistance,
-Missy

Melissa Welsh, CFCS, CPFFE

Doctoral Candidate
Purdue University
Youth Development & Agricultural Education
Agricultural Administration Building Rm. 221
615 W. State St.
West Lafayette, IN 47907
765-496-6881 (office)

Appendix E Research Participant Consent Form

Research Project Number____________________

RESEARCH PARTICIPANT CONSENT FORM
Examining plant scientists experiences, beliefs and values after teaching a K-12 audience

Neil A. Knobloch- Principle Investigator
Melissa L. Welsh- Graduate Research Assistant
Youth Development and Agricultural Education
Purdue University

Purpose of this study: The purpose of this study is to examine the graduate student's reflection of their experience of participating in the YDAE 591 Plant Breeding Education and Outreach Seminar and the YDAE 591 Plant Breeding Research for K-12 Outreach classes. Additional research intent is to examine how the condensed exposure through the YDAE courses to K-12 audiences develops a graduate's beliefs and values in outreach education and bow this affects their value of this experience in the scientific community.

Procedure to be followed during the study: After you return a consent form signed with your full name, your previous reflections from YDAE 591 Plant Breeding Education and Outreach Seminar and the YDAE 591 Plant Breeding Research for K-12 Outreach classroom assignments will be evaluated to determine if you meet the selection for the purposeful sampling. Upon selection, you will receive a follow-up self-efficacy questionnaire and you may be asked to meet with the co-investigator for an interview that will last no longer than 60 minutes in a room equipped with a video camera. The interview will be structured in a format consistent with a job interview for a position requiring experience in outreach education. The distance of the video camera will be consistent with procedures used by job interview training. At any point during the interview you have the opportunity to decline comment on a particular question. During the analysis phase of the study the video will only be seen by the primary or co-investigator and will be locked in a cabinet or on a password secure electronic device of the co-investigator. You will be offered the opportunity to receive a copy of the interview for professional development purposes.

Duration of this Study: The duration of this study is from classes completed in 2011-2013 and interviews conducted in 2013- 2014. All data collected and in the possession of the investigators (i.e., observation notes, reflections, consent forms, recording and transcriptions) will be destroyed within 3 years of this study. The interview will not last more than 60 minutes if you are selected.

Risks: There are no risks to the participants beyond everyday activity at a Research university and during a job interview. There remains a possibility of a breach in confidentiality. Although this risk is a possibility, safeguards are in place to prevent this from happening. All research carries risk. If you chose to receive a copy of the interview, you assume the responsibility of securing your newly acquired property. The standard for minimal risk is that which is found in everyday life.

Benefits: There are no direct benefits to the participants. The intention of the educational component of the project is to develop graduate students intellectual resources in order for them to become more knowledgeable and effective leaders in production agriculture, government, industry and academia. This study also hopes to garner incite from graduate students to continue to progress development of programs to address current academic professional development. You may experience a job interview environment, which may provide a personally beneficial experience for your future job interviews. The results of this study could improve the programs and courses offered to future graduate students studying to be scientists at academic institutions. There are some indirect benefits that may occur to you which include increasing your interest in outreach education and practice for future job interviews.

Compensation: You have the opportunity to request a copy of your job interview video for professional development purposes. Individuals completing the teaching self-efficacy questionnaire will be mailed a $5 Starbucks gift card. Individuals completing the video interview will receive a $25 VISA card.

Confidentiality: Any data collected (i.e., previous class assignment reflections, recordings, field notes) will be stored in a locked desk drawer or on a Purdue password protected computer with access available only to the primary and co-investigator. The project's research records may be reviewed by departments at Purdue University and the Agricultural Food and Research Initiative Grant 91810 Team responsible for regulatory and research oversight. After the conclusion of the study, participants will be given the option to submit their reflection essays and video interviews to their respective graduate departments. After a period of three years following completion of the study and written publications, all data will be destroyed.

Contact Information: If you have any questions about this research project, you can contact Melissa L. Welsh at (724) 388- 6000 or Dr. Neil A. Knobloch at (765) 494-8439. If you have questions about your rights while taking part in the study or have concerns about the treatment of research participants, please call the Human Research Protection Program at (765) 494-5942, email (irb@purdue.edu)or write to:

Human Research Protection Program - Purdue University
Ernest C. Young Hall, Room 1032
155 S. Grant St.
West Lafayette, IN 47907-2114

Documentation of Informed Consent

I have had the opportunity to read this consent form and have the research study explained. I have had the opportunity to ask questions about the research study, and my questions have been answered. I am prepared to participate in the research study described above. I will be offered a copy of this consent form after I sign it.

_______________________________   ____________________
Participant's Signature   Date

____
Participant's Name

_______________________________   ____________________
Researcher's Signature   Date

Appendix F Plant Breeding Education and Outreach Seminar Syllabus Spr 2011

YDAE 59100
PLANT BREEDING EDUCATION AND OUTREACH SEMINAR

Thursdays, 1:30-2:20, BRNG 1260
1 cr. Spring, 2011
CRN: 54860

Instructors
Dr. Neil Knobloch Phone: 494-8439; Email: nknobloc@purdue.edu
Office: 225 AGAD Office Hours: By appointment

Dr. Kiersten Wise Phone: 496-2170; Email: kawise@purdue.edu
Office: 1-325 LILLY Office Hours: By appointment

Teaching Assistant
Annie Davis Phone: 496-6123; Email: aldavis@purdue.edu
Office: 219 AGAD Office Hours: By appointment

Description of Seminar
YDAE 591 is a graduate seminar for graduate students on research assistantships for the AFRI Plant Breeding and Education project. This is a one credit hybrid seminar of online modules and students will meet selected Thursdays for face-to-face discussions. The goal of the seminar is to help develop graduate students as future plant scientists with effective teaching knowledge and skills for K-12 outreach and Extension programs with youth and adult audiences. Students will examine best practices that are grounded in effective teaching and learning for Extension and informal education. Students will learn strategies that promote engagement in field-based and K-12 education settings through Extension presentations and plant science inquiry activities. After taking the seminar, students should have gained understanding of how to create engaging educational programs for youth and adults that are grounded in best practices of informal, nonformal, and formal educational contexts.

Course Goals

At the end of this course, students should be able to:

1. Describe the learner-centered teaching model and identify LCT approaches and strategies that could be used for nonformal education such as Extension

presentations, school enrichment, afterschool programs, skillathons, and youth project workshops.

2. Develop educational plans and active learning resources for youth and adult audiences based on effective engagement strategies.

3. Identify and develop effective Extension publications and communication strategies for the use of nonformal educational programs.

4. Explain the purpose and function of Extension as part of the land-grant university.

Course Requirements

(1) BlackBoard course site - http://www.itap.purdue.edu/tlt/blackboard/index.cfm

(2) LCT Modules – http://www.ydae.purdue.edu/LCT/HBCU/online_course.html

(3) Selected Articles & Resources (will be available via BlackBoard)

Course Assignments

Participants are expected to complete readings and actively participate in class activities. See evaluation checklists for course assignment instructions. Written assignments should be double-spaced, 12 point font, 1 inch margins. Students will largely be citing in the format of APA style. Course grades are based on the following:

- Complete assigned readings and participate in seminar activities (~10%)
    - Read assigned articles
    - Participate in seminar discussions
    - Complete Professional Development Plan for integrating education and Extension activities with research assistantship

- Complete LCT Modules (~30%)
    - Complete Pretests & Post-Tests
    - Complete LCT Modules
    - Reflection on LCT and Proposed K-12 Outreach Ideas

- Philosophy of Extension and Outreach (~20%)
    - After learning about Extension and Outreach: Develop a philosophy statement based on your values, experiences, and interests regarding Extension and outreach

- Extension Specialist Interview Summary (~15%)
    - Meet with an Extension Specialist

    - Summarize the interview in a one-page document and prepare discussion points for group

- Develop a Draft of an Extension Publication (~25%)
    - Research existing Extension publications
    - Develop a draft of an Extension Publication related to your field of study

COURSE SYLLABUS

Date	**Topics**	**Assignment**
Week 1 Jan. 13	Introduction to the Seminar	• LCT Pretests
Week 2 Jan. 20	Introduction to Backward Design and LCT & Extension Specialist Interview	• LCT Module 1 • Schedule an Interview with an Extension Specialist
Week 3 Jan. 27	Designing Learning Objectives	• LCT Module 2
Week 4 Feb. 3	Designing Evidences of Learning	• LCT Module 3
Week 5 Feb. 10	Designing Learning Experiences using Active Learning	• LCT Module 4
Week 6 Feb. 17	Designing Learning Experiences using Inquiry Learning	• LCT Module 5
Week 7 Feb. 24	Designing Learning Experiences using Contextual Learning	• LCT Module 6
Week 8 Mar. 3	Putting All Together and Designing The Course	• LCT Module 7
Week 9 Mar. 10	Seminar Discussion	• LCT Reflection & Proposed K-12 Outreach Ideas • LCT Post-tests
Week 10 Mar. 17	Spring Break	
Week 11 Mar. 24	The Land-Grant University Mission, Extension System & Purposes	• Read article
Week 12 Mar. 31	Discussion of Interviews	• Research Extension Publications • Interview Summary
Week 13 Apr. 7	Discussion of Extension Publications	• Select two Extension publications and bring to seminar this week
Week 14 Apr. 14	Extension Communication	• Philosophy of Extension & Outreach
Week 15 Apr. 21	Planning a Venue for Extension Talks	• Read article
Week 16 Apr. 28	Seminar Discussion	• Draft of Extension Publication
Dec. 13 May 5	Final TBA	• Professional Development Plan

Note: This is a tentative schedule subject to change because of scheduling interferences and student needs.

Grading Scale
Grades will be assigned on a standard scale:

97-100% A+
93-96% A
90-92% A-
87-89% B+
83-86% B
80-82% B-
77-79% C+
73-76% C
70-72% C-
67-69% D+
63-66% D
60-62% D-
<60% F

Important Departmental and Purdue Policies:

Attendance Policy
Students are expected to complete the modules, attend class, and complete the course assignments. [see additional Departmental and University policies below]

Emergency Statement
In the event of a major campus emergency, course requirements, deadlines and grading percentages are subject to change that may be necessitated by a revised semester calendar or other circumstances. Here are ways to get information about changes in this course: Blackboard course Web site, Drs. Knobloch's & Wise's email addresses: nknobloc@purdue.edu or kawise@purdue.edu, and Dr. Knobloch's office phone: (765) 494-8439 & Dr. Wise's office phone: (765) 496-2170.

Academic Integrity & Responsibility
You are expected to do your own work. You need to properly cite ideas that are not your own. Work in this course is to be original work and not an assignment that was completed for another class or project. Furthermore, you are expected to do high quality work and submit your assignment on the dates they are due. All assignments should be turned in at the beginning of class on their due dates. Assignments will receive a letter grade deduction for each day they are late. You are expected to prepare for each class session by reading all assigned resources and fully participating in class discussions. The quality and quantity of comments will be use to determine participation grades.

Course Evaluation Statement

During the last two weeks of the semester, you will be provided with an opportunity to evaluate this course and your instructors. Purdue now uses an online course evaluation system. Near the end of classes, you will receive an official e-mail from evaluation administrators with a link to the online evaluation site. You will have up to two weeks to complete this evaluation. Your participation is an integral part of this course, and your feedback is vital to improving education at Purdue University. We strongly urge you to participate in the evaluation system

Academic Dishonesty Statement

Purdue prohibits "dishonesty in connection with any University activity. Cheating, plagiarism, or knowingly furnishing false information to the University are examples of dishonesty." {Part 5, Section III-B-2-a *University Regulations*; see http://www.purdue.edu/odos/administration/integrity.html} Furthermore, the University Senate has stipulated that "the commitment of acts of cheating, lying, and deceit in any of their diverse forms (such as the use of substitutes for taking examinations, the use of illegal cribs, plagiarism, and copying during examinations) is dishonest and must not be tolerated. Moreover, knowingly to aid and abet, directly and indirectly, other parties in committing dishonest acts is in itself dishonest." [University Senate Document 72-18. Dec.15, 1972]

Adaptive Programs Statement

Students with disabilities must be registered with Adaptive Programs in the Office of the Dean of Students before classroom accommodations can be provided. If you are eligible for academic accommodations because you have a documented disability that will impact your work in this class, please schedule an appointment with one of the instructors as soon as possible to discuss your needs. During this meeting, guidelines provided by the Office of the Dean of Students will be used to develop appropriate alternative instruction and testing methods.

Appendix G Plant Breeding Education and Outreach Seminar Syllabus Spr 2012

YDAE 59100
PLANT BREEDING EDUCATION AND OUTREACH SEMINAR

Thursdays, 1:30-2:20, Pao Hall 1197
1 cr. Spring, 2012
CRN: 54860

Instructors
Dr. Neil Knobloch Phone: 494-8439; Email: nknobloc@purdue.edu
Office: 225 AGAD Office Hours: By appointment

Dr. Kiersten Wise Phone: 496-2170; Email: kawise@purdue.edu
Office: 1-325 LILLY Office Hours: By appointment

Teaching Assistant
Melissa Welsh Phone: 465-6881; Email: welsh2@purdue.edu
Office: 219 AGAD Office Hours: By appointment

Description of Seminar
YDAE 591 is a graduate seminar for graduate students on research assistantships for the AFRI Plant Breeding and Education project. This is a one credit hybrid seminar of online modules and students will meet selected Thursdays for face-to-face discussions. The goal of the seminar is to help develop graduate students as future plant scientists with effective teaching knowledge and skills for K-12 outreach and Extension programs with youth and adult audiences. Students will examine best practices that are grounded in effective teaching and learning for Extension and informal education. Students will learn strategies that promote engagement in field-based and K-12 education settings through Extension presentations and plant science inquiry activities. After taking the seminar, students should have gained understanding of how to create engaging educational programs for youth and adults that are grounded in best practices of informal, nonformal, and formal educational contexts.

Course Goals

At the end of this course, students should be able to:

5. Describe the learner-centered teaching model and identify LCT approaches and strategies that could be used for nonformal education such as Extension presentations, school enrichment, afterschool programs, skillathons, and youth

project workshops.

6. Develop educational plans and active learning resources for youth and adult audiences based on effective engagement strategies.

7. Identify and develop effective Extension publications and communication strategies for the use of nonformal educational programs.

8. Explain the purpose and function of Extension as part of the land-grant university.

Course Requirements

(3) BlackBoard course site - http://www.itap.purdue.edu/tlt/blackboard/index.cfm

(4) LCT Modules – http://www.ydae.purdue.edu/LCT/HBCU/online_course.html

(3) Selected Articles & Resources (will be available via BlackBoard)

Course Assignments
Participants are expected to complete readings and actively participate in class activities. See evaluation checklists for course assignment instructions. Written assignments should be double-spaced, 12 point font, 1 inch margins. Students will largely be citing in the format of APA style. Course grades are based on the following:

- Complete assigned readings and participate in seminar activities (~10%)
  - Read assigned articles
  - Participate in seminar discussions
  - Complete Professional Development Plan for integrating education and Extension activities with research assistantship

- Complete LCT Modules (~30%)
  - Complete Pretests & Post-Tests
  - Complete LCT Modules
  - Reflection on LCT and Proposed K-12 Outreach Ideas

- Philosophy of Extension and Outreach (~20%)
  - After learning about Extension and Outreach: Develop a philosophy statement based on your values, experiences, and interests regarding Extension and outreach

- Extension Specialist Interview Summary (~15%)
  - Meet with an Extension Specialist
  - Summarize the interview in a one-page document and prepare discussion

points for group

- Develop a Draft of an Extension Publication (~25%)
  - Research existing Extension publications
  - Develop a draft of an Extension Publication related to your field of study

COURSE SYLLABUS

Date	Topics	Assignment
Week 1 Jan. 12	Introduction to the Seminar The Land-Grant University Mission, Extension System & Purposes	• LCT Pretests • Read article
Week 2 Jan. 19	Introduction to Backward Design and LCT & Extension Specialist Interview	• LCT Module 1 • Schedule an Interview with an Extension Specialist
Week 3 Jan. 26	Designing Learning Objectives	• LCT Module 2
Week 4 Feb. 2	Designing Evidences of Learning	• LCT Module 3
Week 5 Feb. 9	Designing Learning Experiences using Active Learning	• LCT Module 4
Week 6 Feb. 16	Designing Learning Experiences using Inquiry Learning	• LCT Module 5
Week 7 Feb. 23	Designing Learning Experiences using Contextual Learning	• LCT Module 6
Week 8 Mar. 1	Putting All Together and Designing The Course	• LCT Module 7
Week 9 Mar. 8	Seminar Discussion	• LCT Reflection & Proposed K-12 Outreach Ideas • LCT Post-tests
Week 10 Mar. 15	Spring Break	
Week 11 Mar. 22	Discussion of Interviews	• Research Extension Publications • Interview Summary
Week 12 Mar. 29	Discussion of Extension Publications	• Select two Extension publications and bring to seminar this week
Week 13 Apr. 5	Extension Communication	• Philosophy of Extension & Outreach
Week 14 Apr. 12	Planning a Venue for Extension Talks	• Read article
April 14-15	SPRING FEST	Volunteer Experience
Week 15 Apr. 19	Seminar Discussion	• Draft of Extension Publication
Week 16 Apr. 26	Final TBA	• Professional Development Plan

Note: This is a tentative schedule subject to change because of scheduling interferences and student needs.

Grading Scale

Grades will be assigned on a standard scale:

97-100% A+
93-96% A
90-92% A-
87-89% B+
83-86% B
80-82% B-
77-79% C+
73-76% C
70-72% C-
67-69% D+
63-66% D
60-62% D-
<60% F

Important Departmental and Purdue Policies:

Attendance Policy

Students are expected to complete the modules, attend class, and complete the course assignments. [see additional Departmental and University policies below]

Emergency Statement

In the event of a major campus emergency, course requirements, deadlines and grading percentages are subject to change that may be necessitated by a revised semester calendar or other circumstances. Here are ways to get information about changes in this course: Blackboard course Web site, Drs. Knobloch's & Wise's email addresses: nknobloc@purdue.edu or kawise@purdue.edu, and Dr. Knobloch's office phone: (765) 494-8439 & Dr. Wise's office phone: (765) 496-2170.

Academic Integrity & Responsibility

You are expected to do your own work. You need to properly cite ideas that are not your own. Work in this course is to be original work and not an assignment that was completed for another class or project. Furthermore, you are expected to do high quality work and submit your assignment on the dates they are due. All assignments should be turned in at the beginning of class on their due dates. Assignments will receive a letter grade deduction for each day they are late. You are expected to prepare for each class session by reading all assigned resources and fully participating in class discussions. The quality and quantity of comments will be use to determine participation grades.

Course Evaluation Statement

During the last two weeks of the semester, you will be provided with an opportunity to evaluate this course and your instructors. Purdue now uses an online course evaluation system. Near the end of classes, you will receive an official e-mail from evaluation administrators with a link to the online evaluation site. You will have up to two weeks to complete this evaluation. Your participation is an integral part of this course, and your feedback is vital to improving education at Purdue University. We strongly urge you to participate in the evaluation system

Academic Dishonesty Statement

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Adaptive Programs Statement

Students with disabilities must be registered with Adaptive Programs in the Office of the Dean of Students before classroom accommodations can be provided. If you are eligible for academic accommodations because you have a documented disability that will impact your work in this class, please schedule an appointment with one of the instructors as soon as possible to discuss your needs. During this meeting, guidelines provided by the Office of the Dean of Students will be used to develop appropriate alternative instruction and testing methods.

Appendix H Plant Breeding Research for K-12 Outreach Syllabus Fall 2011

YDAE 59100
PLANT BREEDING RESEARCH FOR K-12 OUTREACH

Fall 2011 1 cr.
CRN: 52592

Instructor
Dr. Neil Knobloch Phone: 494-8439; Email: nknobloc@purdue.edu
Office: 225 AGAD Office Hours: By appointment

Teaching Assistant
Melissa Welsh Phone: 496-3266; Email: welsh2@purdue.edu
Office: 219 AGAD Office Hours: By appointment

Description of Seminar
YDAE 591 is a graduate seminar for graduate students on research assistantships for the AFRI Plant Breeding and Education project. This is a one credit seminar where students will meet periodically for face-to-face discussions. The goal of the seminar is to help develop graduate students as future plant scientists with effective teaching knowledge and skills for K-12 outreach with youth audiences. At the end of the semester, students should have gained an understanding of how to create and apply engaging educational programs for youth that are grounded in best practices of informal, nonformal, and formal educational contexts.

Course Goals

At the end of this course, students should be able to:

9. Develop educational plans and active learning resources for K-12 youth audiences based on effective engagement strategies.

10. Create an assessment plan to evaluate learning outcomes.

11. Teach a youth audience using learner-centered teaching strategies, and reflect on one's own teaching experience.

12. Volunteer and participate at an educational youth program.

Course Requirements

(5) BlackBoard course site - http://www.itap.purdue.edu/tlt/blackboard/index.cfm

(2) Selected Resources (will be available via BlackBoard)

Course Assignments
Participants are expected to complete readings and actively participate in class activities. See evaluation checklists for course assignment instructions. Written assignments should be double-spaced, 12 point font, 1 inch margins. Students will largely be citing in the format of APA style. Course grades are based on the following:

- Participate in seminar activities

- Teach plant science to a K-12 audience
  - Develop an activity that engages K-12 students to learn plant science through active, inquiry or contextual learning.
  - Develop a lesson plan (using a template provided) to teach a lesson to a K-12 youth audience.
  - Self-evaluate one's teaching using a rubric provided and write a one page self-reflection on the teaching experience.

- Serve as a volunteer in one of the following venues, and write a one-page reflection about the event and experience.
  - SpringFest
  - 4-H Round Up
  - 4-H Science Workshops
  - Career Development Event (e.g., Horticulture)
  - Indiana FFA Agriscience Fair (i.e., serve as a judge)
  - National FFA Career Show
  - Other K-12 youth events may be substituted with instructor approval

COURSE SYLLABUS

Date	**Topics**	**Assignment**
Week 1 Aug 25	Seminar Discussion	LCT Reflection & Selected K-12 Outreach Proposals
Week 2 Sept 1	Discussion of writing learning objects using Bloom's Taxonomy	-reflect Module 2
Week 3 Sept 8	Assessment methods and their link to objectives	-reflect Module 3
Week 4 Sept 15	Discussion of Learning experiences using Active Learning	-reflect Module 4
Week 5 Sept 22	Discussion of Learning experiences using Inquiry Learning	-reflect Module 5
Week 6 Sept 29	Accommodation of learning styles	Multiple Intelligences
Week 7 Oct 6	Critical thinking tools and techniques	Tools for Teaching (Barbara Gross Davis)
Week 8 Oct 13	Broadening the interactive learning environment	Role/Advancement of Technology
Week 9 Oct 20	Engaging the learner	50 Creative Training Closers (Lynn Solem, Bob Pike)
Week 10 Oct 27	Lesson Presentations	
Week 11 Nov 3	Lesson Presentations	
Week 12 Nov 10	Lesson Presentations	
Week 13 Nov 17	Seminar Discussion	Reflection of volunteer youth programs
Week 14 Dec 1	Classroom/Group Motivation	Energize Your Audience (Lorraine L. Ukens)
Week 15 Dec 8	Presentation Challenges	Strategies for Great Teaching Moments (Mark Reardon & Seth Derner)
Week 16 FINAL	TBA	

Note: This is a tentative schedule subject to change because of scheduling interferences and student needs.

Grading Scale
Grades will be a (S) satisfactory or (U) unsatisfactory letter based on the degree of work that the student submits.

Important Departmental and Purdue Policies:

Attendance Policy
Students are expected to complete the modules, attend class, and complete the course assignments. [see additional Departmental and University policies below]

Emergency Statement
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Course Evaluation Statement
During the last two weeks of the semester, you will be provided with an opportunity to evaluate this course and your instructors. Purdue now uses an online course evaluation system. Near the end of classes, you will receive an official e-mail from evaluation administrators with a link to the online evaluation site. You will have up to two weeks to complete this evaluation. Your participation is an integral part of this course, and your feedback is vital to improving education at Purdue University. We strongly urge you to participate in the evaluation system

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Appendix I Plant Breeding Research for K-12 Outreach Syllabus Fall 2012

YDAE 59100
PLANT BREEDING RESEARCH FOR K-12 OUTREACH

Thursdays, 4:30-5:20, Pao Hall B157
1 cr. Fall 2012
CRN: 52592

Instructors
Dr. Neil Knobloch Phone: 494-8439; Email: nknobloc@purdue.edu
Office: 225 AGAD Office Hours: By appointment

Teaching Assistant
Melissa Welsh Phone: 496-6881; Email: welsh2@purdue.edu
Office: 219 AGAD Office Hours: By appointment

Description of Seminar
YDAE 591 is a graduate seminar for graduate students on research assistantships for the AFRI Plant Breeding and Education project. This is a one credit seminar where students will meet periodically for face-to-face discussions. The goal of the seminar is to help develop graduate students as future plant scientists with effective teaching knowledge and skills for K-12 outreach with youth audiences. At the end of the semester, students should have gained an understanding of how to create and apply engaging educational programs for youth that are grounded in best practices of informal, nonformal, and formal educational contexts.

Course Goals

At the end of this course, students should be able to:

13. Develop educational plans and active learning resources for K-12 youth audiences based on effective engagement strategies.

14. Create an assessment plan to evaluate learning outcomes.

15. Teach a youth audience using learner-centered teaching strategies, and reflect on one’s own teaching experience.

Course Requirements

(6) BlackBoard course site - http://www.itap.purdue.edu/tlt/blackboard/index.cfm

(2) Selected Resources (will be available via BlackBoard or from the YDAE graduate library)

Course Assignments
Participants are expected to complete readings and actively participate in class activities. See evaluation checklists for course assignment instructions. Written assignments should be double-spaced, 12 point font, 1 inch margins. Students will largely be citing in the format of APA style. Course grades are based on the following:

- Participate in seminar activities

- Teach plant science to a K-12 audience
    - Develop an activity that engages K-12 students to learn plant science through active, inquiry or contextual learning.
    - Develop a lesson plan (using a template provided) to teach a lesson to a K-12 youth audience.
    - Self-evaluate one's teaching using a rubric provided and write a two page self-reflection on the teaching experience.

Grading Scale
Grades will be assigned on a standard scale:

97-100% A+
93-96% A
90-92% A-
87-89% B+
83-86% B
80-82% B-
77-79% C+
73-76% C
70-72% C-
67-69% D+
63-66% D
60-62% D-
<60% F

Important Departmental and Purdue Policies:

Attendance Policy
Students are expected to complete the modules, attend class, and complete the course

assignments. [see additional Departmental and University policies below]

Emergency Statement
In the event of a major campus emergency, course requirements, deadlines and grading percentages are subject to change that may be necessitated by a revised semester calendar or other circumstances. Here are ways to get information about changes in this course: Blackboard course Web site, Dr. Knobloch's email addresses: nknobloc@purdue.edu and Dr. Knobloch's office phone: (765) 494-8439

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Course Evaluation Statement
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Students with disabilities must be registered with Adaptive Programs in the Office of the Dean of Students before classroom accommodations can be provided. If you are eligible for academic accommodations because you have a documented disability that

will impact your work in this class, please schedule an appointment with one of the instructors as soon as possible to discuss your needs. During this meeting, guidelines provided by the Office of the Dean of Students will be used to develop appropriate alternative instruction and testing methods.

COURSE SYLLABUS

Date	Topics	Assignment
Week 1 Aug 23	Seminar Discussion	LCT Reflection & Selected K-12 Outreach Proposals
Week 2 Aug 30	Broadening the interactive learning environment	Role/Advancement of Technology
Week 3 Sept 6	Critical thinking tools and techniques	Tools for Teaching (Barbara Gross Davis)
Week 4 Sept 13	Classroom/Group Motivation	Energize Your Audience (Lorraine L. Ukens)
Week 5 Sept 20	Engaging the learner	50 Creative Training Closers (Lynn Solem, Bob Pike)
Week 6 Sept 27	Accommodation of learning styles	Multiple Intelligences
Week 7 Oct 4	Presentation Preparations- with partner (Not in classroom)	Finalize lesson and supplies
Week 8 Oct 11	Presentation Challenges	Strategies for Great Teaching Moments (Mark Reardon & Seth Derner)
Week 9 Oct 18	Lesson Presentations	
Week 10 Oct 25	Lesson Presentations	

Week 11 Nov 1	Out in the classrooms	
Week 12 Nov 8	Out in the classrooms	
Week 13 Nov 15	Out in the classrooms	
Week 14 Nov 22	No Class Thanksgiving break	
Week 15 Nov 29	Out in the classrooms	
Week 16 Dec 6	Seminar Discussion	Reflection of program/teaching

Note: This is a tentative schedule subject to change because of scheduling interferences and student needs.

Appendix J Pre Teaching Self-efficacy Questionnaire

YDAE 59100
Plant Breeding Education and Outreach Seminar
LCT Pre-test

Beliefs about Teaching and Learning

1. How much can you influence student learning?
   a. Not at all/ none
   b. Very little
   c. Some
   d. Quite a bit
   e. Always/ a lot

2. How much can you challenge student to think more critically?
   a. Not at all/ none
   b. Very little
   c. Some
   d. Quite a bit
   e. Always/ a lot

3. How much can you motivate students to participate in class activities?
   a. Not at all/ none
   b. Very little
   c. Some
   d. Quite a bit
   e. Always/ a lot

4. How much can you engage students to work as a team?
   a. Not at all/ none
   b. Very little
   c. Some
   d. Quite a bit
   e. Always/ a lot

5. To what extent can you create an interactive learning environment?
   a. Not at all/ none
   b. Very little

   c. Some
   d. Quite a bit
   e. Always/ a lot

6. To what extent can you bring real-life experiences to the classroom?
   a. Not at all/ none
   b. Very little
   c. Some
   d. Quite a bit
   e. Always/ a lot

7. To what extent are you prepared to teach the courses you are assigned to teach?
   a. Not at all/ none
   b. Very little
   c. Some
   d. Quite a bit
   e. Always/ a lot

8. To what extent can you clearly communicate the content so students will understand?
   a. Not at all/ none
   b. Very little
   c. Some
   d. Quite a bit
   e. Always/ a lot

9. To what extent can you make students believe they are able to learn and apply the content?
   a. Not at all/ none
   b. Very little
   c. Some
   d. Quite a bit
   e. Always/ a lot

10. To what extent can you adjust your teaching to accommodate different learning styles of students?
    a. Not at all/ none
    b. Very little
    c. Some
    d. Quite a bit
    e. Always/ a lot

11. How effectively can you facilitate an engaging class discussion?
    a. Not at all/ none
    b. Very little
    c. Some
    d. Quite a bit
    e. Always/ a lot

12. To what extent can you incorporate different teaching methods in your lessons?
    a. Not at all/ none
    b. Very little
    c. Some
    d. Quite a bit
    e. Always/ a lot

13. To what extent can you make your expectations clear to students?
    a. Not at all/ none
    b. Very little
    c. Some
    d. Quite a bit
    e. Always/ a lot

14. To what extent can you write clear learning objectives using Bloom's taxonomy?
    a. Not at all/ none
    b. Very little
    c. Some
    d. Quite a bit
    e. Always/ a lot

15. To what extent can you design learning activities to help students to learn the content?
    a. Not at all/ none
    b. Very little
    c. Some
    d. Quite a bit
    e. Always/ a lot

16. How effective can you provide alternative explanations to clarify the main idea?
    a. Not at all/ none
    b. Very little
    c. Some

d. Quite a bit
e. Always/ a lot

17. To what extent can you apply different assessment methods beyond a knowledge test?
    a. Not at all/ none
    b. Very little
    c. Some
    d. Quite a bit
    e. Always/ a lot

18. To what extent can you provide students with specific feedback about their performance to help them to learn?
    a. Not at all/ none
    b. Very little
    c. Some
    d. Quite a bit
    e. Always/ a lot

19. To what extent do you think your students would score well in the exams due to your teaching?
    a. Not at all/ none
    b. Very little
    c. Some
    d. Quite a bit
    e. Always/ a lot

20. To what extent would your students be able to apply the concepts learned in class to real-life situations?
    a. Not at all/ none
    b. Very little
    c. Some
    d. Quite a bit
    e. Always/ a lot

Background

1. What is your gender?
    a. Male
    b. Female

2. What is your position?

a. Ph. D. student
b. Master's student
c. Other (please specify) ______________________________

3. What experience do you have in developing new teaching material or redesigning existing material?
    a. Designed a new learning activity in an existing course (Minor redesign of an existing course)
    b. Redesigned the structure, content and activities of an existing course
    c. Designed a new course
    d. Assisted another to design/ redesign a new/ existing course

Appendix K Follow-up Teaching Self-efficacy Questionnaire

PURDUE UNIVERSITY

Select the answer that best reflects your thoughts and beliefs now.

	Not at all/ None	Very little	Some	Quite a bit	Always/ A lot
How much can you influence students' learning?	○	○	○	○	○
How much can you challenge students to think more critically?	○	○	○	○	○
How much can you motivate students to participate in class activities?	○	○	○	○	○
How much can you engage students to work as a team?	○	○	○	○	○
To what extent can you create an interactive learning environment?	○	○	○	○	○
To what extent can you bring real-life experiences to the classroom?	○	○	○	○	○

Survey Completion

0% 100%

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Survey Powered By Qualtrics

PURDUE UNIVERSITY

Select the answer that best reflects your thoughts and beliefs now.

	Not at all/ None	Very little	Some	Quite a bit	Always/ A lot
To what extent were you prepared to teach the K-12 class you taught?	○	○	○	○	○
To what extent can you clearly communicate the content so students will understand?	○	○	○	○	○
To what extent can you make students believe they are able to learn and apply the content?	○	○	○	○	○
To what extent can you adjust your teaching to accommodate different learning styles of students?	○	○	○	○	○
How effectively can you facilitate an engaging class discussion?	○	○	○	○	○
To what extent can you incorporate different teaching methods in your lessons?	○	○	○	○	○

Survey Completion

0% 100%

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Survey Powered By Qualtrics

PURDUE
UNIVERSITY

Select the answer that best reflects your thoughts and beliefs now.

	Not at all/ None	Very little	Some	Quite a bit	Always/ A lot
To what extent can you make your expectations clear to students?	○	○	○	○	○
To what extent can you write clear learning objectives using Bloom's taxonomy?	○	○	○	○	○
To what extent can you design learning activities to help students to learn the content?	○	○	○	○	○
How effectively can you provide alternative explanations to clarify the main idea?	○	○	○	○	○
To what extent can you apply different assessment methods beyond a knowledge test?	○	○	○	○	○
To what extent can you provide students with specific feedback about their performance to help them to learn?	○	○	○	○	○
To what extent do you think your students would score well on exams due to your teaching?	○	○	○	○	○

Survey Completion

0% 100%

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Survey Powered By Qualtrics

PURDUE
UNIVERSITY

Select the answer that best reflects your thoughts and beliefs now.

	Not at all/ None	Very little	Some	Quite a bit	Always/ A lot
To what extent would your students be able to apply the concepts learned in class to real-life situations?	○	○	○	○	○
To what extent do you feel this series of courses helped you develop your view of teaching?	○	○	○	○	○
To what extent do you feel this series of courses would be beneficial to other graduate students in the College of Agriculture?	○	○	○	○	○
To what extent do you feel this teaching experience will help you in your future career?	○	○	○	○	○
To what extent do you feel the outreach experience (i.e., volunteer experience; Springfest) will help you in your future career?	○	○	○	○	○
To what extent do you feel the Extension education experiences will help you in your future career?	○	○	○	○	○
To what extent do you feel educating a PK-12 audience is important to your professional career?	○	○	○	○	○

Survey Completion

0% 100%

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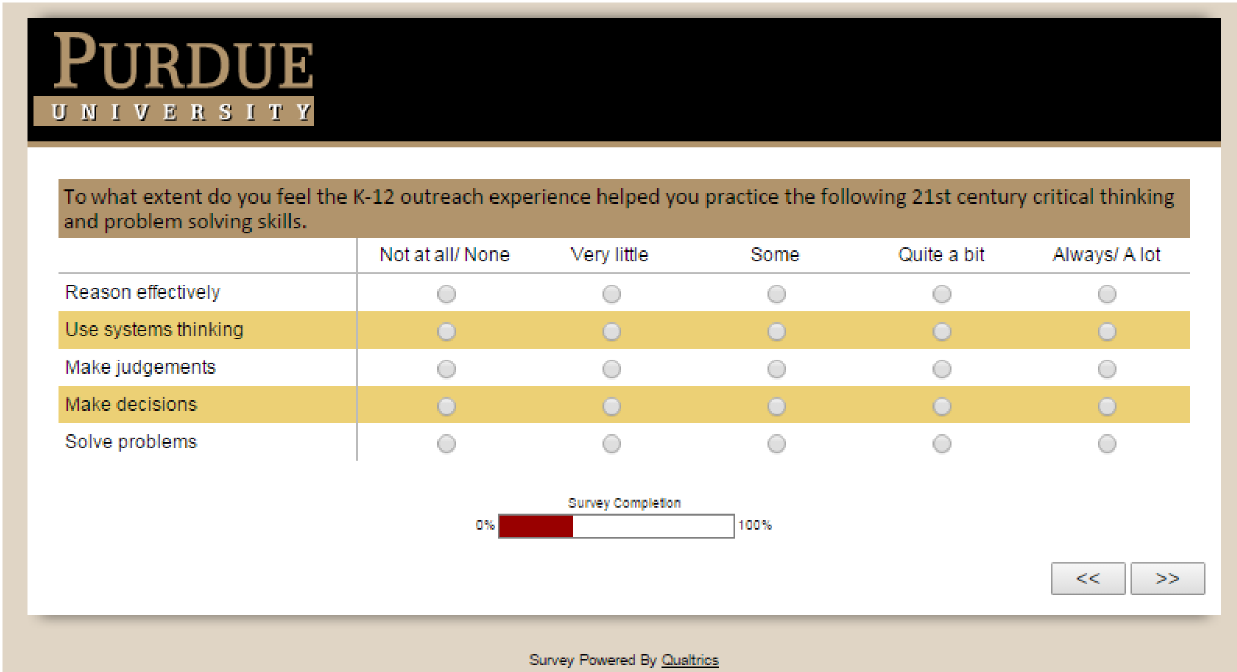
Survey Powered By Qualtrics



PURDUE UNIVERSITY

To what extent do you feel the K-12 outreach experience helped you practice the following 21st century critical thinking and problem solving skills.

	Not at all/ None	Very little	Some	Quite a bit	Always/ A lot
Reason effectively	○	○	○	○	○
Use systems thinking	○	○	○	○	○
Make judgements	○	○	○	○	○
Make decisions	○	○	○	○	○
Solve problems	○	○	○	○	○

Survey Completion

0% 100%

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Survey Powered By Qualtrics

PURDUE
UNIVERSITY

To what extent do you feel the K-12 outreach experience helped you practice the following 21st century creativity and innovation skills.

	Not at all/ None	Very little	Some	Quite a bit	Always/ A lot
Think creatively	○	○	○	○	○
Work creatively with others	○	○	○	○	○
Implement innovations	○	○	○	○	○

To what extent do you feel the K-12 outreach experience helped you practice the following 21st century communication and collaboration skills.

	Not at all/ None	Very little	Some	Quite a bit	Always/ A lot
Communicate clearly	○	○	○	○	○
Collaborate with others	○	○	○	○	○

To what extent do you feel the K-12 outreach experience helped you practice the following 21st century life and career skills.

	Not at all/ None	Very little	Some	Quite a bit	Always/ A lot
Interact effectively with others	○	○	○	○	○
Work effectively in diverse teams	○	○	○	○	○
Manage projects	○	○	○	○	○
Guide and lead others	○	○	○	○	○
Be responsible for science education to others	○	○	○	○	○

Survey Completion

0% 100%

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PURDUE
UNIVERSITY

What is your gender?

- ○ Female
- ○ Male

What is your current status?

- ○ Master's Student
- ○ Doctoral Student
- ○ Graduated and working in a post-doctoral position
- ○ Graduated and working in industry
- ○ Graduated and working in academia
- ○ Graduated and working in a government agency (USDA, NRCS, etc)
- ○ Other ______

Which of the following describes your citizenship status during your time as a student at Purdue University?

- ○ Domestic student (U.S. Citizen)
- ○ International student

What is/was the name of the field of study of your degree program?

- ○ Agronomy
- ○ Botany and Plant Pathology
- ○ Forestry and Natural Resources
- ○ Horticulture & Landscape Architecture
- ○ Youth Development and Agricultural Education

What is/was the name of your graduate advisor?

______

Which of the following best represents your racial or ethnic heritage?

- ○ Non-Hispanic White or Euro-American
- ○ Black, Afro-Caribbean, or African American
- ○ Latino or Hispanic American
- ○ Asian (Far East, Southeast Asia, or the Indian Subcontinent)
- ○ Native Hawaiian or other Pacific Islander
- ○ Middle Eastern or Arab American
- ○ Native American or Alaskan Native
- ○ Other ______

Survey Completion
0% 100%

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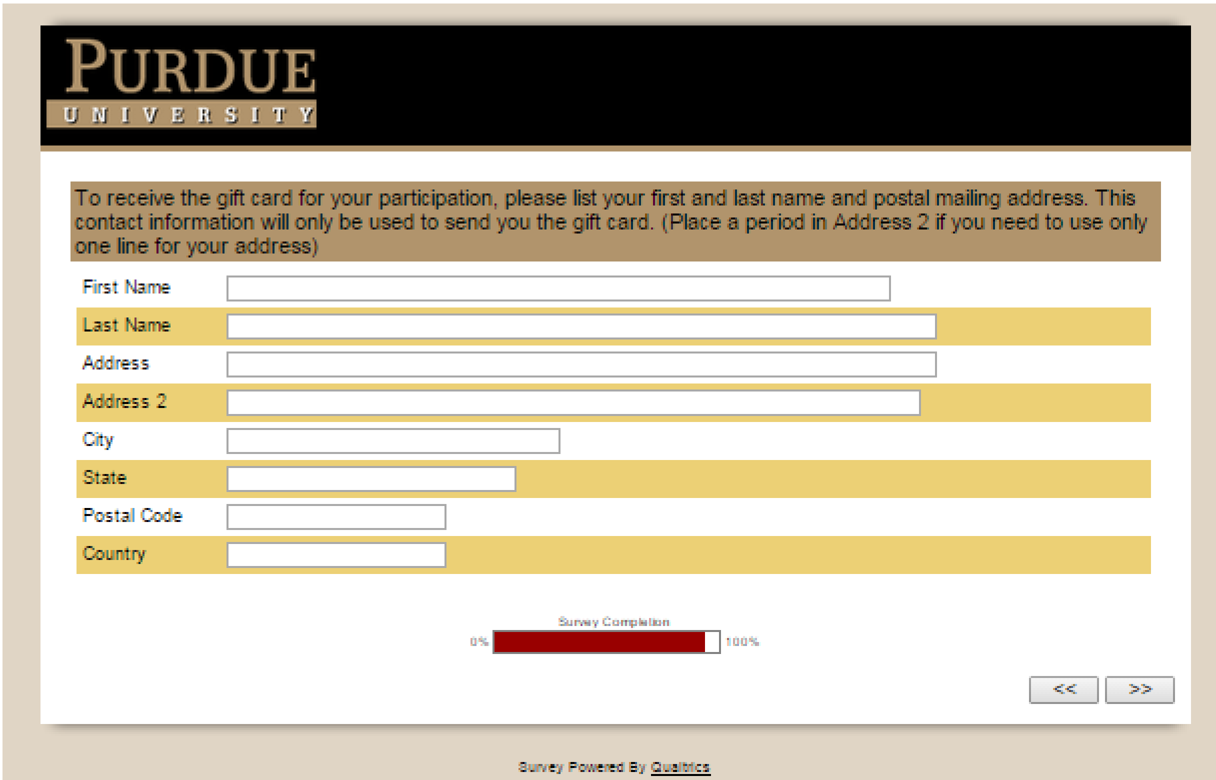

PURDUE
UNIVERSITY

To receive the gift card for your participation, please list your first and last name and postal mailing address. This contact information will only be used to send you the gift card. (Place a period in Address 2 if you need to use only one line for your address)

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Survey Powered By Qualtrics

Appendix L Semi-structured Video Interview Guide

Good afternoon, __________________

It is a pleasure to speak with you today through this follow-up discussion about your participation in the AFRI project and to assist me with questions related to my dissertation. The interview questions are in the format of questions you might encounter if you were interviewing for a research position at a university that required you to complete outreach to K-12 audiences. As a reminder, you are not required to answer any question or questions that you do not want to and if you don't understand something, please ask me.

I want to again assure you that anything you share with me today is confidential. Your name will not be used individually with your responses when reporting the findings of this study.

The interview will be conducted in three parts. The first section will focus on your graduate program. The second will focus on your participation in the AFRI teaching courses. And the third section will focus on the role(s) a scientist encounters in teaching science literacy to K-12 students.

Graduate Program

1) Thinking about your time as a graduate student in the AFRI project, let's start out with you describing your academic and research program.
prompt with:
- a) What is the current status for you at Purdue (Student, Alumni, other)
- b) What is/was the name of the field of study for your Purdue degree program and what level of degree? (M.S./PhD)
- b) Concisely, describe the focus of your research.
- c) Who is/was your advisor?
- d) At what facilities do/did you work or study?
- e) What is/was your career goal?

2) What teaching experiences did you have prior to enrolling in the graduate plant science program?
prompt with: [Graduate personal factors]
- a) How did these experiences assist you in your graduate student duties? How so?
    1. previous experiences teaching K-12 audiences: FFA, 4H, community or religious youth groups

a) positives

b) negatives

2. confidence in your ability to teach about your research, Why?

3) What challenges did you face as a graduate student to begin or continue outreach education?

prompt with: [EVM-cost belief]-personal

a) Did you experience negative aspects of participating in K-12 teaching courses or teaching experiences and how did you navigate these challenges?

4) Did you feel faculty was supportive or act supportive of your participation in the K-12 outreach experiences?

prompt with: [EVM-cost belief]-personal

a) In what ways were they supportive or not supportive?

AFRI Project

Now I would like to shift the discussion to focus upon your thoughts about the non-formal and formal K-12 outreach teaching experiences. First let's focus on the instructional courses that you participated with Dr. Knobloch and Annie Davis or me.

5) Thinking back to your experience in the AFRI teaching courses, what were the key concepts that you learned that were most useful to you?

prompt with: [classes, EVM-utility- personal]

a) Which were most useful?

b) Were there any that were not useful?

b) What was the value or usefulness of this experience to your future goals or career? Why?

c) What does the term "learner centered teaching" mean to you?

6) When you think about using learner-centered teaching strategies, in what ways might you use active learning, inquiry learning and/or contextual learning in your current role? A potential future role?

prompt with: [LCT- class]

a) Active learning

b) Inquiry Learning

c) Contextual learning

7) Now let's focus upon your K-12 outreach experiences- the non-formal (Spring Fest, 4-H, FFA) and the formal in school experience

prompt with: [class- EVM- attainment]

a) Compare and contrast the pros and cons of the non-formal teaching experience. (Spring Fest, 4-H, FFA)

	Non-formal	Formal
Pros		
Cons		

b) Compare and contrast the pros and cons of the formal teaching experience in the K-12 school setting.

c) Do you think these experiences were important for your graduate development? How so?

d) Was one experience more valuable than the other?

1) Beyond the requirements of the class, were there any additional outcomes or goals for you with the K-12 experience?

8) How would you describe your capability to teach a K-12 audience with your research/knowledge of plant science?

prompt with: [TSE]

a) How confident are you (now) in your ability to teach plant science to a K-12 audience?

1. What makes you feel more or less confident in your ability to teach K-12 students?

b) Did the K-12 teaching experience have an impact on your development as a graduate student? If so, how? If no, Why not?

Now I would like to shift the discussion to focus upon your personal and professional thoughts toward scientists engaged in science literacy. To be clear, I'm defining science literacy as "the knowledge of useful science for helping people solve personally meaningful problems in their lives, directly affect their material and social circumstance, shape their behavior, and inform their most significant practical and political decisions"

Science Literacy

9) Do you enjoy teaching others about science?
prompt with: [EVM- Interest/cost belief]-science literacy]

a) How do you see your current role as a scientist in promoting science literacy in the field of plant science research?

1. Is it only research? How so- or Why?
2. Is there a specific audience you would like to focus upon with your information?
3. Do you feel you have a personal responsibility in terms of the research you intend to study and share with K-12 students?

b) Do you believe there is a role scientists play in educating youth (K-12)? If so. What would that role be?

1) Why do you believe this?

10) Is it important is it to you to share your research with others, especially a K-12 audience?
prompt with: [EVM- Utility value/cost belief-science literacy]

a) How important is it to your career to share your research with others, especially a K-12 audience? Why do you feel this way?

1) Do scientists give up something to engage in K-12 outreach? If so, what is/are they giving up?
2) Do scientists gain something by engaging in K-12 outreach?

b) What adjustments do you make when speaking with your audience? Do you adapt language, if so how?

c) Does this conflict or agree with science professionals in your life?

d) How do you feel about the usefulness of the K-12 outreach teaching experiences for graduate students in plant sciences?

11) Assume you are a faculty member advising a graduate student to enroll in an outreach course, what steps would you take to mesh an outreach experience with a graduate student's coursework?
prompt with: [EVM-cost belief]-career readiness

a) What do you believe are the potential benefits in preparing a graduate student using LCT in outreach courses/experiences? Why?
b) What do you believe are the potential drawbacks in preparing a graduate student using LCT in outreach courses/experiences?
c) When would you implement outreach courses with K-12 audiences in a graduate student's plan of work? (or would you?)
d) What would be the major outcome you would want the graduate student to achieve? What would you hope the course on K-12 outreach accomplishes in terms of science literacy?

Wrap up

14) Do you have any additional comments that you would like to share about this experience?
prompt with:

a) Benefits and challenges of the experience?
b) Interesting stories or interactions while in the teaching environment?
c) Are there other important items for me to know about?

Thank-you for participating in this interview.

Would you like to receive a copy of the video for your own professional growth and development purposes?

Do you understand that once you receive the video, you are solely responsible for the confidentiality of your responses to the questions posed by the researchers?

VITA

VITA

Melissa Leiden Welsh

Welsh2@purdue.edu

Campus Residence:

Otterbein, Indiana 47970

Office:

Ag Admin Bldg. Rm. 221
615 W. State Street
West Lafayette, IN 47907
(765) 496-6881

EDUCATION

Ph.D. December, 2014	Purdue University, West Lafayette, Indiana Field of Study: Youth Development and Agricultural Education Specialty Area: Life Science Education Dissertation Title: Graduate Students' Motivation to Teach Plant Sciences to Diverse K-12 Audiences
M.Ed. December, 2009	The Pennsylvania State University, State College, Pennsylvania Field of Study: Agricultural and Extension Education Specialty Area: Youth and Family Education Thesis Title: Financial Practices of Participants After Bankruptcy: Four Steps to a Secure Financial Future
B.S. May, 1999 Studies	Indiana University of Pennsylvania, Indiana, Pennsylvania Field of Study: Human Development and Environmental Specialty Area: Family and Consumer Sciences Education Graduated with Distinction

PROFESSIONAL WORK EXPERIENCES

Youth Development and Agricultural Education Graduate Assistant August 2011 - Present
Purdue University, West Lafayette, IN

Teaching

- Teaching Assistant, YDAE 59100: Translating Research for Extension and K12 Education, 18 students
    - Planned lessons and assignments
    - Facilitated learning activities to demonstrate teaching methods
    - Organized informal learning field experience at SpringFest (a Purdue University educational outreach event)
    - Managed online course management website
    - Assessed student learning and communicated feedback

- Teaching Assistant, YDAE 59100: Plant Breeding Research for K-12 Outreach, 23 students
    - Planned the course and hands-on activities to demonstrate teaching methods
    - Assisted students in the development of teaching plans with constructive feedback
    - Managed online course management website
    - Conducted post-teaching interviews using rubrics and provided constructive feedback

Research

- Managed and analyzed data using SPSS
- Conducted interviews and coded qualitative data
- Reviewed literature
- Managed $15,000 for educational component and professional development of *Partnership for Research and Education in Plant Breeding and Genetics and Purdue University*. USDA NIFA Agricultural and Food Research Initiative Grant.

PK-12 Engagement

- Facilitated networking meetings and Fall 2013 joint council meeting
    - 15 members representing various Departments in College of Agriculture
    - Scheduled guest speakers
- Managed PK-12 Council website

- Coordinated 2013 Fall Purdue University College of Agriculture Outreach and Curriculum showcase
  - Supervised event publicity
  - Secured exhibitors & keynote speaker, Dr. Jason Henderson, Purdue Extension Director and Associate Dean

Family and Consumer Sciences Teacher August 2002 - July 2011
Northern Cambria High School, Northern Cambria School District, Northern Cambria, PA

Teaching

- Family and Consumer Sciences Comprehensive Course
  - Grades 9-12
- Food Science and Nutrition
  - Grades 9-12
- Housing Culture & Interior Design
  - Grades 9-12
- Human Development
  - Grades 10-12
- Alternative Education Program
  - Science, 2002 - 2004

Advising

- Students
  - Northern Cambria Chapter of Family Career and Community Leaders of America, 2004 – 2011
  - Pennsylvania State Affiliation of Family Career and Community Leaders of America State Executive Council of Advisors, 2011
  - Northern Cambria Family and Consumer Sciences Academic Heritage Conference Team Advisor, 2002 – 2011, Conference Champion 2009
  - Heritage Conference Family and Consumer Sciences Academic Chair, 2008 – 2011
  - Junior Class Advisor, 2010 – 2011
  - Student Council Advisor, 2010 – 2011
  - Northern Cambria Forensics Speaking League Advisor, 2006
  - Rising Stars Advisor, 2004
- Faculty
  - Northern Cambria School District Wellness Committee, 2005 – 2011
  - Northern Cambria School District Technology Committee, 2003 – 2006
  - Northern Cambria High School Senate, 2003 – 2010
- Parents
  - Communities in Schools, 2004

Coaching

- Head Coach Boys Track and Field, 2003 – 2006
    - 4 state qualifying athletes

Interior Design Instructor January 2007 - May 2007

Human Development & Environmental Studies Dept., Indiana University of Pennsylvania, Indiana, PA

Teaching

- Housing Culture & Interior Design Course
    - Senior undergraduates

Family and Consumer Sciences Teacher August 1999 - June 02

West Branch Jr./Sr. High School, West Branch Area School District, Morrisdale, PA

Teaching

- 7th Grade Family and Consumer Sciences Comprehensive Course
- 8th Grade Family and Consumer Sciences Comprehensive Course
- Food Science and Nutrition
- Human Development

Advising

- Students
    - Jr./Sr. High School Students Against Destructive Decisions, 1999 – 2003
    - Senior Graduation Project Advisor, 1999 – 2003
- Faculty
    - District Act 48 Committee, (professional development committee)

Coaching

- Assistant Coach Boys and Girls Track and Field, 2000
- Head Coach Boys and Girls Track and Field, 2001 – 2002
    - 1 state qualifying athlete
- Assistant Cross-Country Coach, 1999 – 2002

PROFESSIONAL CERTIFICATES

CFCS, Certified Family and Consumer Sciences (AAFCS)

CPFFE, Certified Personal and Family Finance Educator (AAFCS)

State Board of Private Academic Schools - Nursery/Kindergarten

Commonwealth of Pennsylvania Teaching Certificate - Home Economics

RECOGNITION & ACHIEVEMENTS

- Purdue University College of Agriculture & Youth Development and Agricultural Graduate Student Research Spotlight, 2014
- Purdue University College of Agriculture & Youth Development and Agricultural Graduate Student Teaching Award of Merit, 2014
- YDAE Graduate Student Teaching award, 2014
- Indiana University of Pennsylvania Young Alumni Achiever, 2013
- Purdue Collegiate 4-H Matthew E. Lee 110% Award, 2013
- American Association for Agricultural Education Distinguished Research Poster Presentation, 2013
- Community Scholars: Harlan W. and Dorothy W. Parr Scholarship, 2013
- North American Colleges & Teachers of Agriculture Graduate Student Teaching Award, 2013
- Purdue University Center for Excellence and Teaching Award, 2013
- American Association for Agricultural Education Outstanding Poster Award, 2012
- Golden Key International Honour Society, 2012
- Family, Career and Community Leaders of America Master Advisor, 2010
- American Association of Family and Consumer Sciences New Achievers Award, 2010
- Pennsylvania Association of Family and Consumer Sciences Graduate Scholarship Recipient, 2009
- Who's Who Among America's Teachers, 2000
- Indiana University of Pennsylvania Who's Who Among American College and University Students Scholar, 1997 – 1999
- Pennsylvania State Athletic Conference Scholar Athlete Award, 1997 – 1998

REFEREED RESEARCH PAPERS AND BOOK CHAPTERS *(N = 4)*

Welsh, M. L. & Knobloch, N. A. (In press). Motivation Theories and Strategies to Engage Students. In B. Allison., *Teaching Family and Consumer Sciences in the 21st Century*. Texas: (TBA).

Knobloch, N. A. & Welsh, M. L. (In press). Engaging Students through Learner-Centered Teaching Strategies. In B. Allison., *Teaching Family and Consumer Sciences in the 21st Century*. Texas: (TBA).

Knobloch, N. A., Hains, B., Keefe, L., Chang, S., Espinoza Morales, C., Welsh, M., Balschweid, M., Ballard, T., Liceaga, A., Orvis, K., Snyder, L., Zanis, M., Rossano, M., Silvia, W., Brady, C., Esters, L. T., Latour, M., & Graveel, J. (In press). Enhancing Introductory College Courses Using Educational Games in Animal, Plant and Food Sciences (Mejorando Cursos Universitario Introductorios Usando Juegos Educativos en Zootecnia, Botanica, y Ciencias Alimentarias). Published research paper at the Inaugural International Congress of Innovation in Higher Education for Teaching and Learning Agriculture and Natural Resources, Universidad Nacional Agraria LaMolina, Lima, Peru. Conference website: http://www.lamolina.edu.pe/innovacion2013/

Welsh, M., & Knobloch, N. A. (2013). Future Scientists Philosophical Beliefs Regarding Extension Education and K-12. Paper presented at the 2012 Conference of the American Association for Agricultural Education, The Ohio State University, Columbus, OH.

REFEREED ABSTRACT POSTERS AND PRESENTATIONS *(N = 10)*

Welsh, L. M., & Knobloch, N. A. (accepted). Reflections of Plant Science Graduate Students Engaging K-12 Students While Utilizing Learner-Centered Teaching Strategies. Poster presentation at the 2014 Conference of the North American Colleges & Teachers of Agriculture, Montana State University, Bozeman, MT.

Welsh, L. M., Brown, A., Svedin, E., & Knobloch, N. A. (2013). High School Students Learn about GMOs Using an Inquiry-driven Case Study. Oral presentation at the 2013 Conference of the North American Colleges & Teachers of Agriculture, Virginia Tech University, Blacksburg, VA.

Welsh, L. M., & Knobloch, N. A. (2013). Transdisciplinary Knowledge Transformation by Graduate Students Engaged in an Outreach Experience. Oral presentation at the 2013 Conference of the North American Colleges & Teachers of Agriculture, Virginia Tech University, Blacksburg, VA.

Welsh, L. M., & Knobloch, N. A. (2013). Plant Science Graduate Students' Reflection Ratings of Learner-Centered Teaching After Teaching a K-12 Audience. Poster presented at the 2013 Conference of the American Association for Agricultural Education, The Ohio State University, Columbus, OH. **Distinguished Research Poster Presentation**

Welsh, M. & Knobloch, N. (2013). Plant Science Graduate Students' Reflection Ratings of Learner-Centered Teaching After Teaching a K-12 Audience, Poster presented at the 2013 Purdue University Annual Graduate Student Educational Research Symposium, West Lafayette, IN.

Welsh, M., & Knobloch, N. A. (2012). Perceptions of Learner-Centered Teaching Experiences by Graduate Students in Plant Sciences Teaching a K-12 Audience. Poster presented at the 2012 North Central Region Conference of the American Association for Agricultural Education, University of Illinois, Urbana-Champaign, IL. **Outstanding Poster Award**

Welsh, M., Knobloch, N., & Ohm, H. (2012). Sustaining Agriculture Through Graduate Directed K-12 Outreach Experiences. Oral presentation at the 2012 Conference of the North American Colleges and Teachers of Agriculture, River Falls, WI.

Welsh, M., Davis, A., & Knobloch, N. (2012). Graduate Student Training in K-12 Education & Outreach: Partnership for Research and Education in Plant Breeding and Genetics. Poster presented at the 2011 Purdue University Chapter: The Society of Sigma Xi Poster Session, West Lafayette, IN.

Welsh, M. (2010). Financial Practices of Participants after Bankruptcy: Four Steps to a Secure Financial Future. Poster presented at the 2010 AAFCS Community of Colleges, Universities and Research, Research Poster Session, Chicago, IL.

Welsh, M. (2007). Empowering Students Using Nutrition Learning Modules: Implications for Agricultural Education. Poster presented at the 2007 North Central Region Conference of the American Association for Agricultural Education Innovative Poster Session, Columbia, MO.

NON-REFEREED PAPERS AND PRESENTATIONS *(N = 7)*

Welsh, M., & Knobloch, N. A. (2013). Transdisciplinary Knowledge Transformation by Graduate Students Engaged in an Outreach Experience. Poster presented at Spring Purdue University Next Generation Scholars Research Fair, West Lafayette, IN.

Welsh, M., & Knobloch, N. A. (2013). Plant Science Graduate Students' Reflection Ratings and Observations of Learner-Centered Teaching After Teaching a K-12 Audience. Oral presentation at Purdue University Office of Interdisciplinary Graduate Programs Spring Reception, West Lafayette, IN.

Welsh, M., & Knobloch, N. A. (2013). Perceptions of Learner-Centered Teaching Experiences by Graduate Students in Plant Sciences Teaching a K-12 Audience. Poster presented at the Fall 2012 Purdue Plant Science Poster Session, West Lafayette, IN.

Espinoza-Morales, C., Xu, S., Orvis, K. S., Knobloch, N. A., & Welsh, M. (2012). Plants Get Sick Too! Poster presented at Purdue University Next Generation Scholars Research Fair, West Lafayette, IN.

Welsh, M., & Knobloch, N. A. (2012). Perceptions of Learner-Centered Teaching Experiences by Graduate Students in Plant Sciences Teaching a K-12 Audience. Poster presented at Fall Purdue University Next Generation Scholars Research Fair and the Fall 2012 Purdue Plant Science Poster Session, West Lafayette, IN.

Welsh, M., Knobloch, N. & Ohm, H. (2012). Sustaining Agriculture through Graduate Directed K-12 Outreach Experiences. Poster presented at the Spring 2012 Purdue Plant Science Poster Session, West Lafayette, IN.

Welsh, M., Davis, A., & Knobloch, N. (2011). Graduate Student Training in K-12 Education & Outreach: Partnership for Research and Education in Plant Breeding and Genetics. Poster presented at the Fall 2011 Purdue Plant Science Poster Session, West Lafayette, IN.

GRANT REPORTS *(N = 2)*

Welsh, M., & Knobloch, N. (2013). Partnership for Research and Education in Plant Breeding and Genetics and Purdue University. USDA NIFA Agricultural and Food Research Initiative Grant Education Component Evaluation Summary. Unpublished report to Purdue University.

Welsh, M., & Knobloch, N. (2012). Partnership for Research and Education in Plant Breeding and Genetics and Purdue University. USDA NIFA Agricultural and Food Research Initiative Grant Education Component Evaluation Summary. Unpublished report to Purdue University.

RESEARCH AND PROGRAM GRANTS *(N = 5, Cumulative total = $29,000)*

Ohm, H. W., Anderson, J., Doerge, R., Ejeta, G., Jackson, S., Knobloch, N., McCann, M., Mickelbart, M., Rocheford, T., Tuinstra, M., Weil, C., Williams, C., Wise, K., & Woeste, K. Partnership for Research and Education in Plant Breeding and Genetics and Purdue University. USDA NIFA Agricultural and Food Research Initiative Grant. (January 1, 2010 to December 31, 2013). Funded, $995,334 total ($497,672 received & matched), Welsh (as research assistant) was responsible for managing $15,000 of grant for education component.

Welsh, M., Kosto, J., & Wargo, M. (2009). Northern Cambria High School Healthy Actions, Highmark Blue Cross and Shield, Highmark Healthy Schools Grant, $10,000, Funded.

Welsh, M., Kosto, J., & Wargo, M. (2008). Northern Cambria Nutrition and Fitness Fair. Pennsylvania Department of Health. PANA Grant, $3,000, Funded.

Welsh, M. (2007). Northern Cambria Nutrition Fair. Pennsylvania State Beef Council. Pennsylvania Beef Council Matching Grant, $500, Funded.

Welsh, M. (2003). Technology Interfused with Family and Consumer Sciences Curricula. Pennsylvania Association of Family and Consumer Sciences, PAFCS Program Grant, $500, Funded.

OUTREACH/ ENGAGEMENT SERVICE

Professional

- U.S. Army eCYBERMISSION STEM Judge (2012 – 2013)
- American Association of Family and Consumer Sciences Building Leadership Capacity Committee (2011 – Present)
- North Central Region Conference of the American Association for Agricultural Education Session Facilitator (2012 – 2013)
- American Association of Family and Consumer Sciences National Conference Session Moderator (2012)
- American Association of Family and Consumer Sciences Personal and Family Finance Educator Assessment Development Panel 2011

University

- Purdue University Collegiate 4-H Member (2011– present)
    - Purdue University Collegiate Officer, 4-H Technology Director (2013 – 2014)
- Purdue University Graduate Student Government, YDAE Senator (2013 – 2014)
- Purdue University Life Science Education Signature Area Member (2011 – Present)
- Purdue 4-H Animal Science Workshop, Rabbit Science Co-Chair (2013)
- SpringFest, Partnership for Research and Education in Plant Breeding and Genetics: Agricultural and Food Research Initiative Grant (AFRI) Display Coordinator (2012 – 2013)
- Indiana State 4-H Dairy Judging Career Development Event, Session Facilitator (2012)
- National Science Teachers Association, Session Co-Facilitator, Developing Learner-Centered Teaching Activities (2012)
- National Science Teachers Association, YDAE Education & Outreach Display Co-Exhibitor (2012)
- Indiana State 4-H Youth and Adult Congress, Session Instructor (2011 – 2012)
- Indiana State 4-H Horticulture Career Development Event, Session Facilitator (2011)
- YDAE Graduate Student Group Recruitment Coordinator (2011)

CURRENT PROFESSIONAL MEMBERSHIPS

American Association of Family and Consumer Sciences (AAFCS)
American Association for Agricultural Education (AAAE)
American Camp Association (ACA)
American Educational Research Association (AERA)
Indiana Association of Family and Consumer Sciences (AAFCS-IN)
National Association of Extension 4-H Agents (NAE4-HA)
North American Colleges & Teachers of Agriculture (NACTA)
Pennsylvania Association of Family and Consumer Sciences (PAFCS)

FAMILY BUSINESS & COMMUNITY

Leiden Land and Cattle Company Inc., Secretary & Tri-Owner
St. Francis Church, Member
Arbor Day Foundation, Member
Pennsylvania Association of Family Career and Community Leaders of America, Volunteer
Autism Speaks Walk, Volunteer

Updated 12/2014