Developing Research and Extension Skills of Undergraduate Students in Integrated Agronomic Systems

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Abstract

Developing undergraduate student skills in conducting research and communicating findings in the emerging area of integrated agronomic systems is increasingly important. Undergraduates in agricultural colleges are often trained in individual facets of their disciplines and not necessarily in research and extension activities in integrated agronomic systems. To address this, we hosted 24 undergraduate students for 10 weeks in three summers (2016, 2017, and 2018) at the University of Nebraska-Lincoln. The students conducted research experiments in cropping systems, forage systems, and soil science, and participated in workshops and extension activities. The scholarly outputs included extension articles and poster presentations at national meetings. We assessed their response to research and extension involvement through pre- and post-internship surveys with survey questions on a 5-point Likert scale of 1 (strongly disagree) to 5 (strongly agree). The post-internship survey showed interns valued the social aspects of the program, research products, and presentation of research findings. The interns also valued integrating theory into practice, exploring scientific literature, interpreting research data and others although the mean rating decreased by -0.01 to -0.92 points between pre- and post-internship surveys. Students scored extension activities high, gaining 54 to 63% in confidence after shadowing extension educators and networking opportunities. Interns perceived importance in working with their faculty mentor and other interns and faculty. The post-internship survey showed that the internship instilled a greater interest in careers related to agriculture and 57% enrolled in graduate school. Overall, internships enhance research and extension skills of undergraduate students in integrated agronomic systems.

Introduction

Developing professional skills of undergraduate students in agricultural science is increasingly important. Between 2018 and 2028, the need for agriculture and food scientists and technicians is expected to increase 6 to 7% faster than the average for most careers (BLS, 2020). Indeed, for 2020, the average estimated number of graduates (35,000) is lower than the average estimated number of jobs (60,000) for high-skill agricultural jobs (USDA, 2015). Thus, a need exists for attracting students to agriculture and similar fields. One way to attract students to these fields is by offering well-designed internship programs.

Undergraduate curriculum often focuses on coursework. As such, it may not instill rigorous research training in field and laboratory work nor strong research and extension communication skills (Blanco-Canqui et al., 2018; Field et al., 2017; Krzic et al., 2015; Hartemink et al., 2014). Properly-designed undergraduate internships can be an effective strategy to teach research and extension communication skills while networking with peers and professionals in an applied learning context. While benefits of internships for hands-on experiential learning, exploring potential new careers, and increasing chances for employment in different disciplines are well known (Hynie et al., 2011; Good et al., 2013; VanMeter-Adams, 2014; Binder et al., 2015; Howell et al., 2019), most internships only prepare students for one facet of their chosen field and not for integrated and multi-disciplinary careers. For example, many undergraduate research internships focus on research and not on the combination of research with extension activities, such as shadowing (Hansen et al., 2019). Crop consultants, researchers, extension personnel, and others often have to integrate a variety of skills and disciplines in order to make proper recommendations.

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Literature on internships in physical and life sciences including human nutrition and food sciences shows students typically view the internship positively and report increases in skill proficiency (Kardash, 2000; Good et al., 2013). For example, Kardash (2000) reported that undergraduate students who interned with physical or life science faculty self-reported an average skill improvement of 20% across 13 research skills. As another example, interns in human nutrition, foods, and exercise sciences, reported increased ability to conduct research, somewhat increased ability for public speaking, and no change in their abilities of writing or understanding statistics in pre and post program surveys (Good et al., 2013). Similar data from internships in agricultural research integrated with extension is lacking (Kardash, 2000; Good et al., 2013).

One research-based agricultural internship showed that internships can improve student research skills (Marsh et al., 2016). For example, after their internship, interns rated acquiring critical thinking, developing hypotheses, conducting literature reviews, solving a research problem, managing data, and gaining communication skills 23% higher (Marsh et al., 2016). Similarly, extension internships can be beneficial for undergraduate students (Rogers et al., 2001; Wilken et al., 2008; Muscio, 2011; Grotta and McGrath, 2013). For instance, Musico (2011) found that extension internships improved skills in the use of spreadsheets or databases, presentation skills, and other select skills in 80% of interns. Yet, the internships discussed previously did not integrate research with extension across different facets of agriculture including crop science, forages, livestock, soil science, and others.

It is also essential to assess the effectiveness of an internship (Muscio, 2011; Grotta and McGrath, 2013; Good et al., 2013). Pre- and post-internship surveys can be a method to assess how integrated agriculture internships in research and extension benefited students. In this study, we assessed how undergraduate intern responded to research and extension activities through pre- and post-internship surveys with the ultimate goal of the interns transitioning to graduate school in an agronomic, crop, and soils research area.

Materials and Methods

We recruited 24 interns with an interest in agronomic, crop, plant, soil, or related sciences from land grant universities, community colleges, and minority-serving institutions across the US to participate in a 10-week summer research and extension internship over three summers (2016, 2017, and 2018) at the University of Nebraska-Lincoln.

Student Recruitment and Selection

We used three strategies to recruit students for our internships. First, we contacted some of our colleagues in other universities to encourage their students to apply to this internship program at University of Nebraska-Lincoln. Second, we placed announcements with the American Society of Agronomy (ASA), the Soil Science Society of America (SSSA), and the Crop Science Society of America (CSA). Collectively, these organizations represent more than 12,000 members, many of whom are affiliated with colleges and universities. Third, we collaborated with the Nebraska Summer Research Program (NSRP) organized by the University of Nebraska-Lincoln Office of Graduate Studies. The NSRP hosts a website with program information and a centralized application platform to recruit applicants through direct contact with undergraduate programs across the country, particularly minority-serving institutions. Some of the benefits of the internship being connected to NSRP are that interns were housed together in dormitories, which allowed interns from different disciplines to connect, attend seminars, and travel together, and allowed for another opportunity for the interns to share their posters.

Applicants submitted a cover letter detailing their experience in research, plant science, soil science, agronomy, or related fields, future plans, curriculum vitae, college transcripts, and two letters of recommendation. Applicants also responded to two questions: “How would this research experience help you to meet your educational goals?” and “Describe your previous experience and/or personal strengths that would benefit a research team?”. We invited up to 10 students to participate each summer based on the following criteria: passion and intellect in agronomic, crop, plant, soil, or related sciences; interest in earning an advanced degree (Master’s or Ph.D.); and possession of diverse talents and skills to bring to the research team; displaying passion for research and/or extension work; evidence of high academic achievement and preparation to carry out research; evidence of teamwork and independent problem-solving skills; and recommendations from faculty regarding academic performance.

Among the interns, information from a faculty member at their home institution was the primary way they learned about the internship (n=12, 50%). Several interns also mentioned receiving an email from University of Nebraska-Lincoln about the program (n=9, 38%). A few interns mentioned learning about the internship by conducting a Web search (n=4, 17%), outreach from a University of Nebraska-Lincoln faculty member (n=2, 8%), or encouragement from a previous intern (n=2, 8%). Due to the sample size and sample selection process being purposive, the results should not be generalized beyond the sample.

Table 1 summarizes the interns’ demographics. The interns were primarily female (n=21, 88%), white (n=15, 63%) and junior (50%) or senior (42%) students (Table 1). Seven (29%) interns indicated they were eligible for a Pell Grant at their home institution. Most of the interns (n=14, 58%) had previous research experience prior to the internship. Many of the interns (n=7, 29%) had prior experience with extension programs as 4-H members. The high percentage of female interns was potentially due a variety of factors. First, the intern pool may have had more qualified female than male applicants. For example, Lewin (2006) discusses how females are more conscious of how they appear on paper and work harder in their classes than males. Second, females have traditionally been underrepresented in STEM fields, a trend that has persisted in some STEM fields like agriculture (Xu, 2016). Thus, in order to facilitate female enrollment in STEM fields, those with interest and/or those

Table 1. Demographics of 2016-2019 summer research interns.

Demographic	Frequency
Gender	
Female	21
Male	3
Ethnicity	
White	15
American Indian	2
Black	2
Hispanic	3
Asian	1
No Response	3
Level	
Sophomore	1
Junior	11
Senior	9
Fifth-year Senior	2
Post-baccalaureate	1
Prior research experience	
Yes	13
No	8

that display a certain propensity for the field, are highly encouraged to pursue those degrees (Xu, 2016). Third, males may have different preferences or career goals after graduation, and may prefer to enter the workforce directly.

Student Learning Outcomes

Our learning outcomes for the summer research internship included:

1. Interns will understand integrated agronomic systems (i.e., use of cover crops and annual forages in corn and soybean cropping and pasture systems).
2. Interns will learn how agronomic experiments are designed and arranged in corn and soybean cropping and pasture systems.
3. Interns will learn how to measure and analyze fundamental agronomic variables such as stand establishment, crop phenology, vegetative cover, species identification, and soil properties.
4. Interns will learn how to develop an extension case study to address a specific concern from producer. In developing the case study, interns will learn how to frame the concern as a question, conduct an appropriate literature review to identify evidence-based practices, identify experts in the field to consult with regarding their findings, and communicate their findings with the producer.
5. Interns will learn how to effectively communicate about their extension and research work verbally and in writing.

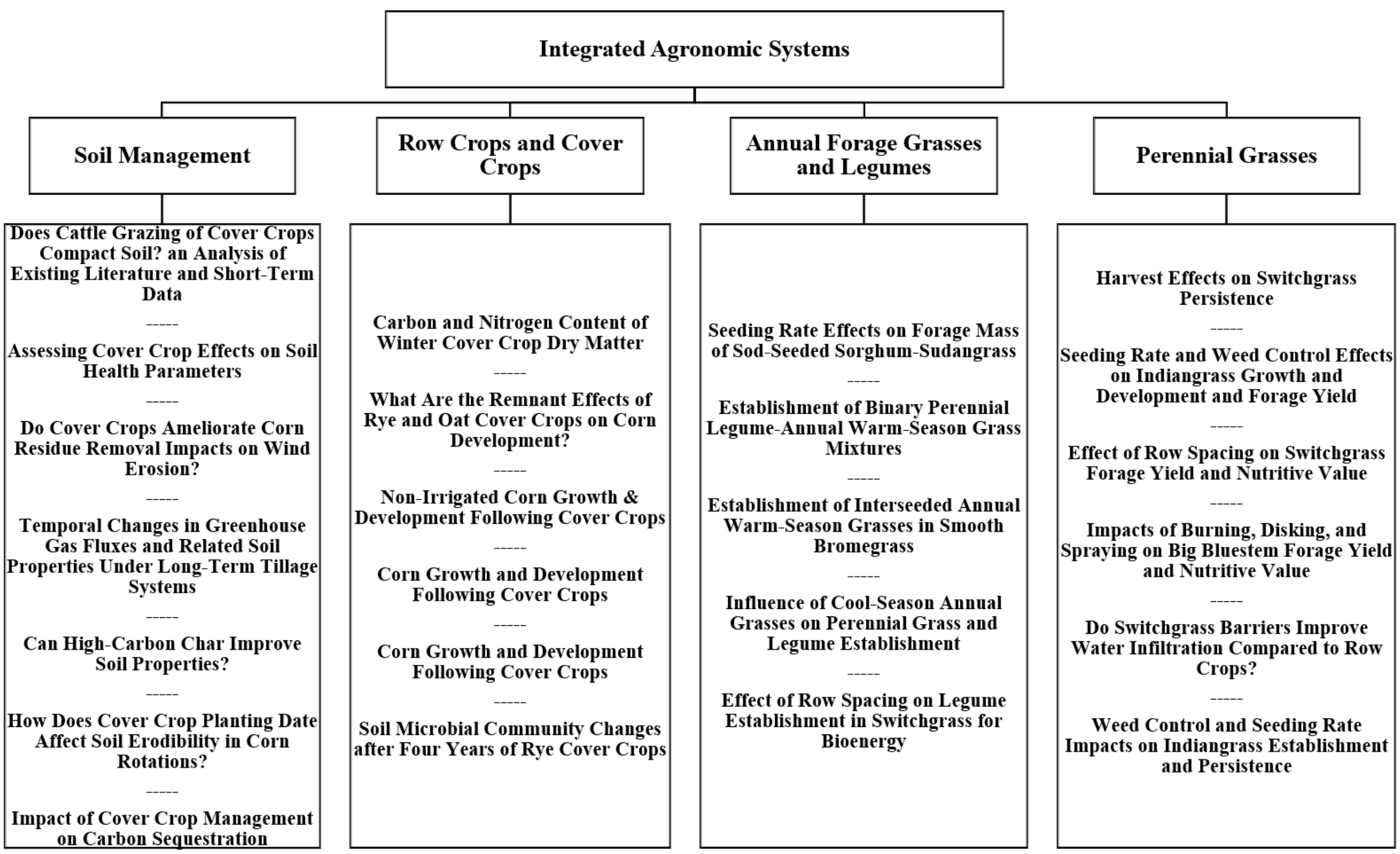

Figure 1. Integrated agronomic systems undergraduate summer research and extension program areas and projects conducted by the summer interns.

6. Interns will develop networks with other students, government scientists, industry leaders, faculty, and extension personnel in the field of integrated agronomic systems.
7. Interns will learn specific skills necessary to apply to graduate school.

Student Research and Mentoring

We paired student interns with one of four faculty mentors specializing in row crops and cover crops, annual forage systems, perennial grasses, or soil management. Interns selected a topic to research in coordination with their mentor that was original or supporting research (Fig. 1). Original research projects were those developed by the mentor. Interns selected a topic to research in coordination with their mentor that was either an original topic developed by the mentor or a side project in support of an existing research project that would otherwise not have been accomplished (Fig. 1). Deconstructed research included understanding the project by identifying hypotheses and methods and analyzing the data in small portions as described by Clark et al. (2009). Guided by their mentors, technicians, postdoctoral associates, and graduate students in the mentors' labs, interns learned how to conduct a literature review, the proper techniques for collecting plant and soil samples, procedures for analyzing their data, and how to communicate their results effectively. It is important to note that given the growing season in Nebraska and the summer program dates, interns sometimes conducted analysis on data collected prior to their arrival.

Interns prepared a report and poster of their findings. They presented the poster at three events: 1) Agronomy Department summer research symposium, 2) a campus-wide research symposium that showcased posters of all university interns, and 3) the ASA-CSSA-SSSA International Annual Meeting in the fall or winter after the internship. Our program provided funding for interns to attend and present their project at the International Annual Meeting. Throughout the internship, interns were encouraged to assist each other in all facets of research to exchange ideas, address research questions, gain experience, build camaraderie, and complete tasks. Table 2 details the program activities over the course of the 10 weeks.

To enhance the learning experience, we provided interns with tours of public, private, and federal research stations throughout Nebraska as well as a series of professional development workshops that included:

1. Corn and soybean cropping systems, cover crops, crop residue management, soil management, integrated crop-livestock systems, pasture management, and climatic, economic, cultural, and environmental challenges.
2. Developmental morphology and physiology of corn, soybean, cover crops, and annual forages.
3. Crop establishment considerations including species and cultivar selection, pH and fertility, legume inoculation, seeding rates and depth, time of planting, seeding methods, weed management, and compatibility of species mixtures.
4. Crop residue management, cover crops, and perennial grasses and their implications on soil conservation and other soil ecosystem services.
5. Experimental design, an overview of the scientific method, developing hypotheses, defining the inference space, selecting factors to be studied, selecting variables to be measured, selecting experimental units, developing the layout, writing the model, and specifying the analysis.
6. Weekly seminars for interns to enhance their knowledge of research fundamentals and current literature, how to make effective presentations, provide feedback on presentations by interns, and enhance their scientific writing skills.

Student Extension Experiences

In addition to conducting research, interns were engaged in several different outreach or extension activities to gain knowledge and experience with the role of extension education in integrated agronomic systems. These activities included learning about web-based extension programming through seminars and workshops, extension educator shadowing for two days with a different educator each day, touring farms in the University of Nebraska-Lincoln On-Farm Research Network (https://cropwatch.unl.edu/on-farm-research), and attending several other field days. While shadowing an extension educator, interns toured additional farms and learned about local soils, visited about day-to-day activities, conducted crop stand counts, pest and disease scouting, and diagnostics, and discussed different approaches to stakeholder engagement (social media and technology vs. publications vs. on-farm visits). The field days on weeds, soil health, and crops facilitated participant interaction and discussion with farmers, industry personnel and presenters in addition to learning about the various topics presented. The interns each wrote an extension article for applied audiences based on their research project which are available online (Fig. 1) (CropWatch March 15, 2019; CropWatch February 16, 2018; CropWatch November 18, 2016). The preparation of these articles allowed the students to disseminate the results of their project to a different audience than those for the research poster.

Assessment of the Research and Extension Experiences

Matriculation to graduate school in a crop and/or soils research area was one of the long-term goals for students and the focus of our mentoring activities and student learning outcomes. We measured interest in graduate school, along with other skills related to research and careers in Science, Technology, Engineering, and Mathematics (STEM) through pre- and post-internship surveys. The NSRP collected general survey data from interns through SurveyMonkey (SurveyMonkey, 2019) in week one and week ten of the internship. We collected supplemental survey data specific to interest in extension through in-person paper and pencil surveys during the same time frame, in addition to conducting, pre-, mid-, and post-internship focus groups. The survey was conducted using a 5-point Likert scale (1 through 5 scale with responses of 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree).

Table 2. Timeline of internship activities for 10-week research and extension integrated agronomic systems summer internship.

Week	Research Activities	Extension Activities	Professional Development
1	• Welcome and orientation • Safety training • Preliminary survey • Research ethics training • Introduction to grain crop, pasture and soils research of mentors		
2	• Begin work on research projects • Learn about equipment used in agronomic, crop, and soil science research		
3	• Continue research work	• Learn about web-based extension programming • Tour farms participating in University of Nebraska-Lincoln On-Farm Research Network in south central Nebraska	
4	• Continue with research work	• Shadow an extension educator • Tour farms participating in University of Nebraska-Lincoln On-Farm Research Network in southeastern Nebraska	
5	• Begin analysis and interpretation of data and write-up results	• Develop a CropWatch article about their research projects	
6	• Continue with research experiments and analysis of data	• Develop and practice of extension presentations • Writing a CropWatch article	• Tour Monsanto Water Utilization Learning Center at Gothenburg
7	• Continue with research experiments and analysis of data	• Deliver presentation to extension clientele at Nebraska Extension field day	
8	• Submit first draft of research report and assist with research projects of mentors		
9	• Practice research presentations with faculty mentors		• Tour USDA-ARS forage and biomass energy research plots near Mead
10	• Submit final research reports • Complete final survey		• Deliver final presentation at University of Nebraska-Lincoln undergraduate research symposium • Attend student sendoff celebration
Post-intership	Attend International Annual Meetings of the ASA-CSSA-SSSA in the fall. Present research poster created during internship, participate in undergraduate research programs, and network with peers and faculty.		

Table 3. Student responses to how the interns rated career fields pre- and post-internship. On a scale of 1 to 5 with 1 being "strongly disagree and 5 being "strongly agree."

Statement	Pre Mean±SD	Post Mean±SD	Change in Plans
I plan to pursue a career in…			
1. Agriculture	2.92±1.47	3.52±0.87	0.60
2. Extension	3.00±0.74	3.05±0.78	0.05
3. Agronomy	2.88±1.12	2.90±1.14	0.02
4. Soil Science	2.39±1.20	2.29±1.06	-0.10
5. Integrated Agronomic Systems	2.74±1.25	2.53±1.17	-0.21

Table 4. Student responses to how the program improved understanding of research, technology, ideas, professional development, and entrepreneurship skills. On a scale of 1 to 5 with 1 being "strongly disagree and 5 being "strongly agree."

Statement	Mean±SD
The Nebraska Summer Internship Program improved my understanding of research and development in my field.	3.64±1.11
The Nebraska Summer Internship Program increased my interest in the commercialization of ideas and technology in my field.	3.15±1.23
The Nebraska Summer Internship Program improved my professional development and entrepreneurship skills.	3.54±1.22
The Nebraska Summer Internship Program gave me a broader understanding of and interest in interdisciplinary research in my field.	3.60±1.25

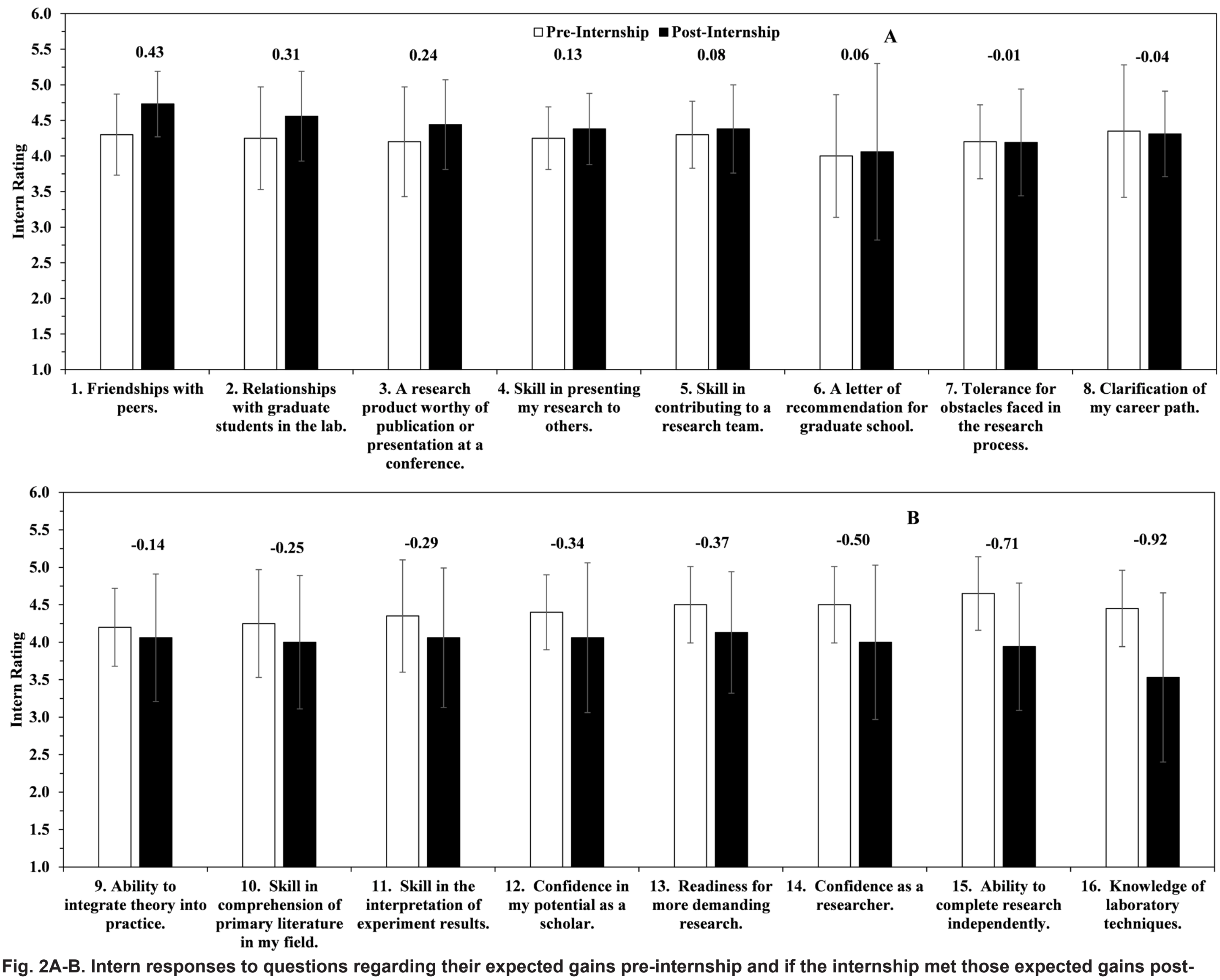

Fig. 2A-B. Intern responses to questions regarding their expected gains pre-internship and if the internship met those expected gains post-internship. On a scale of 1 to 5 with 1 being "strongly disagree and 5 being "strongly agree."

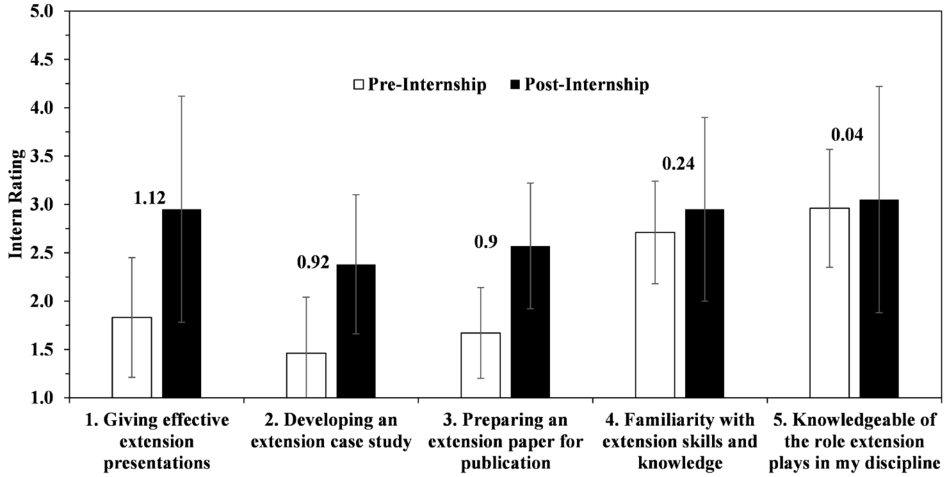

Fig. 3. Student responses to questions regarding confidence in extension pre- and post-internship. On a scale of 1 to 5 with 1 being "strongly disagree and 5 being "strongly agree."

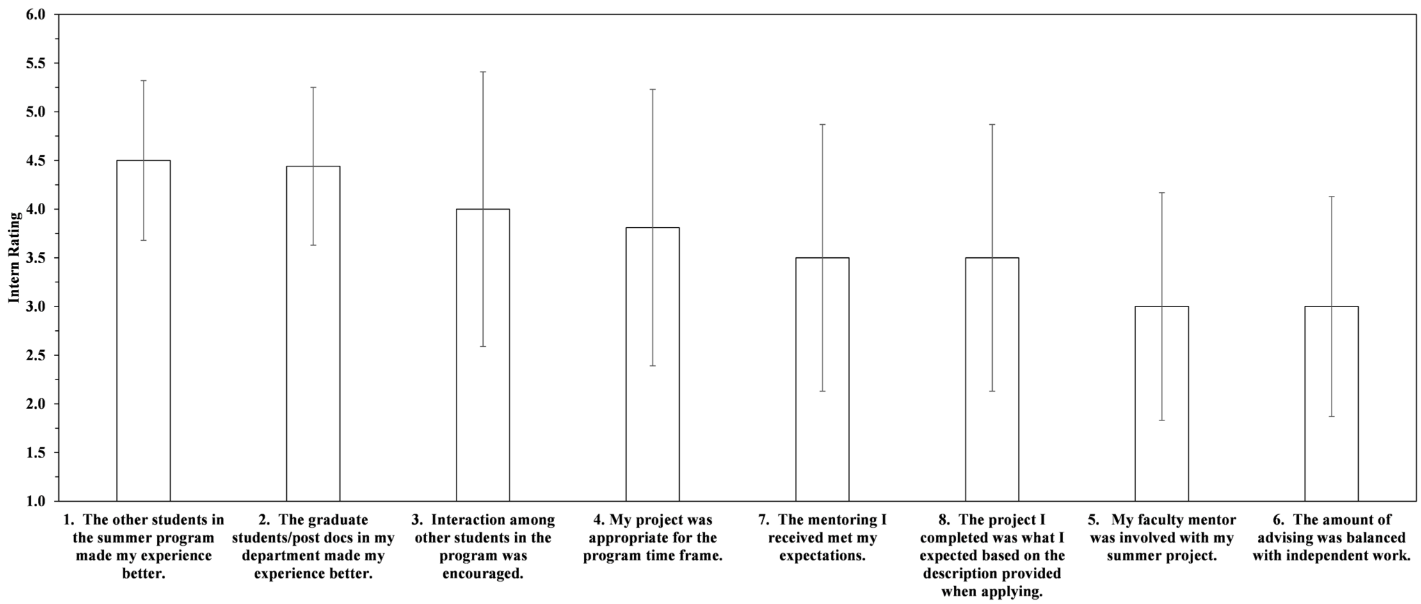

Fig. 4. Student agreement to statements regarding their interactions with their mentor and others and their specific research project. On a scale of 1 to 5 with 1 being "strongly disagree and 5 being "strongly agree.

The pre-internship questionnaire included questions on how confident the interns were in research skills including conducting experiments, scientific writing, and presentations, and in understanding extension as well as how to present extension case studies. It also included questions on what the students hoped to gain through the experience including skills, social functions, and readiness for the next phase of their careers. The final part of the pre-internship questionnaire was about their current career plans. The post-internship survey included the previous questions plus questions regarding their project, their interactions with their mentor and others, and general questions about the program. The survey questions and responses are shown in Tables 3-4 and Fig. 2-4.

Data Analysis

We downloaded data from SurveyMonkey and then transferred it to the Statistical Package for the Social Sciences (SPSS, 2019). We entered the paper and pencil data directly into SPSS. We then computed means and standard deviation for each question by pre or post internship. We did not use t-tests or other statistical procedures to compare pre- and post-internship responses due to lack of intern responses on some questions or lack of response to the follow-up survey by some interns.

Results and Discussion

Intern Gains in Skills

Figure 2 summarizes participant responses to what they expected to gain and what they actually gained in terms of skills from the internship experience. Based on Fig. 2, interns typically agreed with statements regarding various aspects of the program or research skills in both pre- and post-internship survey. The interns showed the greatest gains (0.24 to 0.43 points) between the pre- (4.20 to 4.30) and post-internship (4.44 to 4.73) surveys for statements of: friendships with peers, relationships with graduate students in the lab, and a research product worthy of publication or presentation (Fig. 2A). The interns reported small gains

(0.08 to 0.13) regarding presentation of research and skill in contributing to a research team between the pre- (4.25 to 4.30) and post-internship (4.38) survey (Fig. 2A). These responses suggest that the social functions of the program (i.e., working with and time spent with the other interns and graduate students) and having an end-product from the internship were highly valued aspects of the program. The positive responses of our interns to having a product to present (Lopatto, 2007) and various other social functions of the program are similar to those in other STEM fields (Sloan et al., 2016).

While not directly related to gains in skills, three statements: letter of recommendation for graduate school, tolerance for research obstacles, and clarification of career path showed no change between the pre- and post-internship surveys (Fig. 2A-B). The lack of change in these questions may be due to the already high agree response (>4.00) in the pre-internship survey.

Several questions regarding expected gains (questions 9-16, Fig. 2B) were rated -0.14 to -0.92 points lower in the post-internship (3.53 to 4.13) than pre-internship survey (4.20 to 4.65). The statements with the greatest rating reductions between pre- and post-internship were: confidence as a researcher (-0.50), ability to conduct research independently (-0.71), and knowledge of laboratory techniques (-0.92), which may indicate that a 10-week program or how the program is structured is not sufficient to allow gains in these particular areas. It is interesting to note that skills in interpreting results, literature comprehension, and readiness for more demanding research showed <10% reductions in expected gains. Many of the internship participants had prior research experience, which may explain the small gains in some research skills. However, the rigor of the combined research-extension internship may have surprised some participants leading to the reductions in expected gains at the end of the internship. The minimal or lack of gains in some research skills in Table 3 is in line with intern responses in other disciplines (Kardash, 2000).

Regarding extension, the interns began the internship rating skills in extension (Fig. 3) 1.46 to 1.83 and knowledge and familiarity as 2.71 to 2.96. However, by the end of the summer, the interns showed 0.04 to 1.12 point increases in confidence in preparing an extension paper for publication, developing an extension case study, and giving effective extension presentations. These gains were likely due to the first hand experiences gained by writing an extension paper which was subsequently published online and by giving an extension presentation. However, the interns reported only small gains in familiarity with extension skills, knowledge, and the role of extension, which may in part be due to the observational (passive) role of shadowing versus the experiential (active) role they had in writing the CropWatch article.

Student Assessment of Mentorship, Interactions with Others, and Their Specific Projects

Figure 4 summarizes student response to statements regarding mentorship, interactions with others, and their specific project. Interns generally agreed (3.50 to 3.81) that their mentor was accessible, a benefit, communicated regularly, and was interested in working with them. These perceptions were accomplished through weekly meetings with the interns and the integration of the interns into the greater research group of each mentor, which increased the number and diversity of intern-researcher interactions. Further, mentors often worked directly with the interns on sample collection, analysis, data management, and development of the poster. Interns responded neutrally to agree (3.5 to 3.8) on questions regarding how involved the mentor was in the project and that the mentoring met expectations. The lower response to these questions suggests further mentoring and involvement may be needed in some cases.

It can be difficult to determine the level of mentorship each participant required in the first couple weeks of the internship. However, careful discussions of related activities on their resume or curriculum vitae may elucidate the level of mentorship needed by each participant. For example, an intern who was involved with soil or crop judging but not with research, likely has stronger background in those areas and may need more mentorship in research. By contrast, an intern that had previous research experience in a laboratory but did not have soil or crop management experience may need more mentorship in field data collection and operations. Studies evaluating animal science student response to mentors during internships have reported that learning plans developed by the intern can facilitate learning in internships (Anderson, 2015). Further, in medical fields, others have reported that frequent contact between the mentor and intern fosters learning and ensures the intern is on track to complete tasks in a timely manner (Howell et al., 2019). The previous studies from medical fields on mentor-intern interactions supports our findings.

The interns rated working with the graduate students and post-doctoral associates as well as interaction with other students in the program as 4.0 to 4.5 (Fig. 4) and indicated it improved their overall experience. These responses or perceptions were accomplished through integrating the interns within their respective research groups. These interactions allowed the interns to discuss graduate school experiences with the graduate students and post-doctoral associates, allowed for further mentorship opportunities, mentorship of a different style, and first-hand learning opportunities. For example, in at least two of the research groups, the interns worked extensively with a post-doctoral associate or graduate student on their project. The interns appeared to have better experiences when they worked collaboratively on similar projects than individually. For example, in year 1, the two interns in the soil management group worked on separate projects and had little collaboration between them. However, in the same group in year 3, the two interns worked on different aspects of the same project, often analyzing samples together.

Interns agreed (3.8) that their projects were appropriate for the time frame (Fig. 4). Interns did, however, respond more neutrally (3.5) to the project being what they expected based on the description provided when applying (Fig. 4). The mentors met with their interns shortly after their arrival to pair the intern with an appropriate project. The lower rating on the question regarding the project description matching the intern's expectation likely reflects changes to the availability of the project or the intern selecting a different project based on discussions with their mentor. For example, two interns switched research work from forages to soil management projects within the first couple of weeks of the program.

Career Goals and the Overall Internship Experience

Table 3 summarizes participant responses to questions regarding career field selection pre- and post-summer research internship. Prior to the summer internship, the interns did not plan to or were unsure about pursuing a career in agronomy, agriculture, integrated agronomic systems, soil science, or extension. However, after the internship, participant ratings of plans to pursue a career in agriculture increased by 0.60 and extension by 0.05 points. This increase suggests the internship positively affected their outlook on careers in agriculture. Two yes or no questions regarding future plans in terms of graduate school and extension careers were also included in the questionnaire. After completing the internship, seven interns were considering an extension career, three were planning on an extension career, eight were in graduate school, four were planning on graduate school, and one was considering graduate school. Only one participant responded that they were not considering an extension career, and one responded they were not planning on graduate school.

Table 4 describes participant responses to statements regarding the internship overall. The interns responded neutral to agree (3.54 to 3.64) that the internship improved understanding of research in the field, improved professional development, and gave broader understanding and interest in research in their field. They responded more neutrally (3.15) that the internship increased interest in commercialization of ideas and technology in the field. These data indicate that the program did slightly improve intern understanding of research, interest in the field, and professional development.

Challenges and Potential Solutions

The internship program provided guidance and many positive experiences for the interns; however, the program was not without challenges. The first challenge was determining the skills and backgrounds for each intern, so mentoring could be tailored appropriately. For example, some of the research interns had little experience in soils or agronomy and needed more mentoring and support in these aspects. Others, however, had extensive soils knowledge through participation in soil judging or other activities but did not have research experience. Knowing prior skillsets and background is therefore critical to targeting and enhancing the research experience and knowledge gained by the interns.

A second challenge is the short timetable for the internship. A typical graduate research program lasts 2 years for a Master's degree and a typical college semester runs about 15 weeks. Our summer research internship was only 10 weeks (Table 1), indicating that the project had to fit within the days allocated to research or extension while remaining days were allocated to tours or other activities. The time split often left about 3 days per week for research activities. Further, the interns started in early June, after crop planting, cover crop termination, and typical soil sampling periods, and the interns completed the internship in mid-August, before crop harvest. This meant that the interns often missed some of the critical periods of plant or soil data collection. The short time table also led to compressed windows for completing statistical analysis and tended to reduce learning opportunities for statistical analysis toward the end of the program. Creating the posters was a time-consuming activity and was often the first poster the majority of the interns had created, which did increase stress and frustration for some interns. Scaling back on the amount of data collected and increasing time for statistical analysis and interpretation would be beneficial for future internships. Alternatively, a blend of data given to the participant plus some they collect during their internship could be a potential compromise.

A third challenge is the mentor-mentee relationship. This included differences in expectations and tolerance to perceived stressors, such as the completion of the poster. The differences in expectations could be alleviated through the same clear expectations delivered from all mentors and by encouraging the interns to tackle the larger tasks in smaller pieces.

The fourth challenge is following-up with the interns for the post internship surveys. The email addresses students gave at the beginning of their summer research experience were typically their college emails. These emails often expire 6 to 12 months after graduation, which, along with lack of response, can make following up with the interns for the post internship surveys difficult.

Conclusions

This study on the perceptions of 24 summer experiential research and extension interns in a 10-week summer integrated agronomic systems internship showed that, in general, the internship enhanced skills of undergraduate students. Participant perception of having a research product to present and skills in presenting research improved between the pre- and post- internship surveys. However, interns reported no gains in confidence regarding certain research skills (integrating theory into practice, comprehending primary literature, and interpreting results) suggesting the 10-week internship is not sufficient to teach all aspects of research effectively. The extension aspects of preparing paper for publication, developing an extension case study, and giving effective extension presentations showed the greatest gains in confidence. Interns sometimes found their research project different from what they expected but typically rated their experience with their mentor positively. The social aspects of the internship, including collaboration among interns and working with graduate students, post-doctoral associates, and technicians were rated very positively by the interns, suggesting that a multi-mentor approach can be useful. The research and extension internship also appeared to increase appreciation for agriculture as there was a 0.60 point increase in favorability for taking a job in this field. Overall, integrated agronomic systems internships that allow for experiences in research and extension can improve skills of undergraduate students in these areas.

Literature Cited

Anderson, K.P. 2015. Evaluation of undergraduate equine related internship experience by students and employers. North American Colleges and Teachers of Agriculture Journal 59: 234-239.

BLS. U.S. Bureau of Labor Statistics. 2020. Life, physical, and social science occupations. Occupational Outlook Handbook. Accessed 25 June 2020 from: https://www.bls.gov/ooh/life-physical-and-social-science/home.htm.

Blanco-Canqui, H., S, Ruis, C. Speth and D. Lee. 2018. Teaching undergraduate soil management to diverse majors: Linking lectures with field practicals. Natural Sci. Ed. 47: 180017.

Blanco-Canqui, H., S.J. Ruis, C. Speth and D. Lee. 2019. Integrating writing into undergraduate soil management course enhances student learning. Natural Sci. Ed. 48: 1900040.

Binder, J.F., T. Bauley, C. Crook and F. Miller. 2015. The academic value of internships: Benefits across disciplines and student backgrounds. Contemporary Educational Psychology 41: 73-82.

Clark, I.E., R. Romero-Calderon, J.M. Olson, L. Jaworski, D. Lopatto and U. Banerjee. 2009. “Deconstructing” scientific research: A practical and scalable pedagogical tool to provide evidence-based science instruction. PLoS Biol. 12: e1000264.

CropWatch March 15 2019. Student researchers tackle timely crop topics. https://cropwatch.unl.edu/2019/march-15-2019.

CropWatch February 16, 2018. Students report on soil, forage, and cover crop research. https://cropwatch.unl.edu/2018/february-16-2018.

CropWatch November 18, 2016. Student research. https://cropwatch.unl.edu/2016/universitynebraskacropwatch-nov-18-2016.

Field, D.J., A.J. Koppi, L.E. Jarrett, L.K. Abbott, S.R. Cattle, C.D. Grant, A.B. McBratney, N.W. Menzies and A.J. Weatherly. 2011. Soil Science Teaching Principles. Geoderma 167-168: 9-14.

Good, D.J., C.M. McIntyre and M.A. Marchant. 2013. The USDA scholars program: Innovations in a summer undergraduate research program. North American Colleges and Teachers of Agriculture Journal 57: 62-70.

Hartemink, A.E., M.R. Balks, Z.S. Chen, P. Drohan, D.J. Field, P. Krasilnikov, D.J. Lowe, M. Rabenhorst, K. van Rees, P. Schad, L.A. Schipper, M. Sonneveld and C. Walter. 2014. The joy of teaching soil science. Geoderma 217-218: 1-9.

Howell, L.P., S. Wahl, J. Ryan, R. Gandour-Edwards and R. Green. 2019. Educational and career development outcomes among undergraduate summer research interns: A pipeline for pathology, laboratory medicine, and biomedical science. Academic Pathology 6: 1-10.

Junge B., C. Quiñones, J. Kakietek, D. Teodorescu and P. Marsteller. 2010. Promoting undergraduate interest, preparedness, and professional pursuit in the sciences: an outcomes evaluation of the SURE program at Emory University. CBE Life Sciences Education 9: 119–132.

Kardash, C.M. 2000. Evaluation of an undergraduate research experience: Perceptions of undergraduate interns and their faculty mentors. Journal of Educational Psychology 92: 191–201.

Krzic, M., A.A. Bomke, M. Sylvestre and S.J. Brown. 2015. Teaching sustainable soil management: A framework for using problem-based learning. Nat. Sci. Edu. 44: 43-50.

Lewin, T. 2006. A new gender divide. At colleges, women are leaving men in the dust. The New York Times. nytimes.com/2006/07/09/education/09college.html. December 14, 2020.

Lopatto, D. 2004. Survey of Undergraduate Research Experiences (SURE): First findings. Cell Biology and Education 3: 270–277.

Lopatto, D. 2007. Undergraduate research experiences support science career decisions and active learning. CBE-Life Sciences Education 6: 297-306.

Marsh, L.E., F.M. Hashem, C.P. Cotton, A.L. Allen, B. Min, M. Clarke and F. Eivazi. 2016. Research internships: A useful experience for honing soft and disciplinary skills of agricultural majors. North American Colleges and Teachers of Agriculture Journal 60: 379-384.

Motavalli, P.P., M.D. Patton, R.A. Logan and C.J. Frey. 2003. Promoting environmental writing in undergraduate soil science programs. J. Nat. Resour. Life Sci. Ed. 32: 93-99.

Muscio, C. 2011. Exit surveying of interns: Demonstrating impact on young professionals. Journal of Extension 49: 3tt5.

Rogers, B., K. Mason and J. Cornelius. 2001. Involving undergraduate students as extension program interns. Journal of Extension 39: 5IAW4.

Sloan, V., R. Haacker, T. Barnes and C. Brinkworth. 2017. Long-term impacts of a career development workshop for undergraduates. American Meteorological Society 98: 1961-1967.

SPSS, 2019. IBM SPSS Statistics Software, Corporate Headquarters, Armonk, NY 10504-1722.

SurveyMonkey, 2019. SurveyMonkey Software Company, San Mateo, CA 94403.

USDA-NIFA. United States Department of Agriculture-National Institute of Food and Agriculture. 2015. One of the best fields for new college graduates? Agriculture. https://nifa.usda.gov/press-release/one-best-fields-new-college-graduates-agriculture. Accessed June 25, 2020

VanMeter-Adams, A., C.L. Frankenfeld, J. Bases, V. Espina and L.A. Liotta. 2014. Students who demonstrate strong talent and interest in STEM are initially attracted to STEM through extracurricular experiences. CBE-Life Sciences Education 13: 687-697.

Wilkin, C.S., B.C. Williams, N. Cadavieco and D.K. Walker. 2008. Student internships in extension: Strategies for success for the agent and the student. Journal of Extension 46: 4TOT3.

Xu, Y.J. 2016. Aspirations and application for graduate education: Gender differences in low-participation STEM disciplines. Research on Higher Education. 57: 913-942.