Student Perceptions of Mentoring Practices During Undergraduate Research Experiences

Carol Speth[1], Salvador Ramirez II[1], Rachel Ibach[2], Donald Lee[1], Leah Sandall[1], Martha Mamo[1], Jennifer Keshwani[2], David Lambe[1], Gina Matkin[3], and Walter Schacht[1]
University of Nebraska-Lincoln
Lincoln, NE

Abstract

Research experiences for undergraduate (REU) students are valuable for exploring STEM professions. Students from underrepresented groups and non-research institutions may not have the opportunities to engage in hands-on research. A primary goal of our Applied Plant Systems REU was to provide authentic research experiences for students who may not have the chance. Mentoring is key to the success of a REU, yet intentional mentoring is not often prioritized. Over three summers, we explored student perception of the value of mentoring within an agricultural STEM REU. Pre- and post-survey responses were analyzed, and we found that the students valued specific aspects of mentoring during their REU. Interestingly, at the end of the REU, the survey result showed that the students placed a higher importance on items such as mentoring being a systematic process and that mentoring is based on friendship. There is clear indication that students know good mentoring when they experience it, even if it is not verbalized. Based on the survey responses and comments from students involved in this REU, we developed practical mentoring items which can be incorporated into research programs to enhance the mentoring experience.

Keywords: mentoring, undergraduate research, STEM education

Science research experiences for undergraduate (REU) students are useful to gain insight into the research process. Students who have limited to no exposure to research have the chance to work on a project and practice the skills needed for science efficacy, being part of a community of scientists and exploring their identity as a professional in science, technology, engineering, and mathematics (STEM) (Estrada et al., 2018). Mentoring during REUs is essential for students to be supported and guided as they work on research projects. Positive experiences can then contribute to self-perceived progress and help them view the REU as a success. The Applied Plant Systems (APS) summer research experience aimed to provide skills and mentoring to create a holistic approach to engaging students.

STEM Research Experience in Agriculture and Mentoring

Providing opportunities for experiences in STEM career areas can enlighten and encourage students to pursue careers in STEM/Agricultural STEM. The APS program provided students the chance to envision themselves in a career focused on discovery and technology applications for improving plant and soil systems. Acquiring research skills, working on a team, and reflecting on the process are essential to being a successful STEM professional. The APS program emphasized creating a positive mentoring experience for both the student and the faculty research leader. Mentoring is a valuable and often undocumented aspect of a faculty member's contribution to the mission in a research-leading institution. Mentoring benefits undergraduate and graduate students (Retallick & Pate, 2009) and the faculty mentor (Potter et al., 2009). Research focused institutions elevate their mission when faculty can systematically improve their mentoring skills and students experience effective mentoring. Mentors can contribute to the students' science efficacy, identity, and community, as well as career development. The combined influence of these factors can determine the career decisions of undergraduates (Estrada et.al, 2018). Fifolt and Searby (2010) emphasize the importance of internship programs outside of the STEM curriculum in guiding students to be

1 Department of Agronomy and Horticulture, University of Nebraska-Lincoln
2 Biological Systems Engineering Department, University of Nebraska-Lincoln
3 Department of Agricultural Leadership, Education and Communication, University of Nebraska-Lincoln
Correspondence concerning this article should be addressed to Leah Sandall, Department of Agronomy and Horticulture, University of Nebraska-Lincoln, 279L Plant Sciences Hall, Lincoln, NE 68583; Email: lsandall5@unl.edu

better protégés for their mentors. An evaluation of student response to mentoring in a REU program can guide faculty mentoring growth. To evaluate the mentoring in this project, we sought items that were theoretically sound and pre-tested (Retallick and Pate, 2009).

Applied Plant Systems REU Program Hypotheses

The APS program sought to evaluate the role of mentoring and research experiences with students. The hypotheses for the APS program were:

1. Students will report a progression in confidence in their own research skills as a result of mentoring experiences.
2. Students will report mentoring experiences helped guide their educational and career pathways in agricultural STEM.
3. Student responses to mentoring approaches will vary and can guide mentoring improvement for faculty.

Methods

Recruitment and Student Selection

The APS program occurred during summer of 2017, 2018 and 2019. The project was funded by a grant from USDA-National Institute of Food and Agriculture (#2017-67032-26018). This study was approved by the University of Nebraska Institutional Review Board for the protection of human subjects, as Project ID# 30456: "Fostering the next generation of agricultural and natural resources professionals through experiential learning in research, education, and extension." Undergraduate students were recruited in collaboration with the University of Nebraska-Lincoln (UNL) Office of Graduate Studies and the Office of Undergraduate Research. These two offices centralize all summer REU programs at UNL by providing recruitment, application, and selection services, as well as providing logistical support for student housing, access to campus facilities, and student enrichment programs.

A team of co-PIs selected APS students based on academic achievement, professional goals, class standing (sophomore or junior), underrepresentation, and reference letters. The selection team considered each applicant's research goals to match applicants with a project of interest. In years 2 and 3, more emphasis was placed on selecting applicants from smaller, non-research focused institutions. Twenty-three total interns completed the program over three years. Six completed the APS program in 2017, eight in 2018 and nine in 2019 (Table 1).

When they applied for the program online, applicants received a description of the projects available. By choosing their research area, they indirectly selected their mentor. In some mentoring relationships there was also a graduate student, post-doc or technician who served as an unofficial mentor to APS interns. In all cases, interns had a team of people they worked with including other undergraduates and research technicians. The size of the research team and the balance between team vs. individual work varied among projects.

Students arrived on the UNL campus as a cohort in late May and had a 10-week experience. The program covered travel, on-campus housing, and meals. The APS team consisting of faculty, staff, and a graduate student hosted each of the three student cohorts. The APS team complemented the UNL REU program and provided some social events and connections.

Mentoring and Research Experience

The APS team selected mentors based on the expectation they would provide mentoring, teaching, and encouragement to the intern. Mentors were expected to be motivated to advance the science within their respective disciplines by preparing a future workforce. While the APS program provided the summer stipend for the intern, the research mentor was responsible for fully integrating the

Table 1.

Interns Self-Identified Gender, Race/Ethnicity and Home Institution Type for the Applied Plant Systems REU Program

Year	Number of interns	Gender	Asian, Asian-White Asian-Pacific Islander	Black Black-White	Hispanic Hispanic-Black Hispanic-Indigenous Hispanic-White Hispanic-Indigenous-Black-White	White	Institution type
2017	6	1M/5F			1	5	5R/1NR
2018	8	2M/6F	1	1	1	5	3R/5NR
2019	9	2M/7F	1		2	6	1R/8NR

Note. M = male; F = female; R = research; NR = non-research student into their summer research team.

The various research topics interns could select in their application included: (1) soil science and soil microbiology, (2) rangeland, grassland, and fire ecology, (3) plant breeding, (4) field crop and horticulture management, (5) entomology, and (6) on-farm research. Mentors were asked to help students design experiment hypotheses, conduct the research, and practice skills necessary in STEM careers.

Science Communication

The interns shared about their individual research projects and the decisions they made related to their research during weekly Friday Think Tank Sessions (TTS) organized by the APS team. Friday TTS included tours designed to introduce the cohort to Extension at a land grant university and to show the integration of private company research in Nebraska production systems. TTS engaged the interns in discussion, providing them with the opportunity to practice a range of professional skills including communication, leadership, and entrepreneurship.

The interns developed a scientific poster at the end of the REU explaining the research they conducted with their mentor. During the TTS, the APS leadership team provided poster design guidance and critique. Interns presented their summer research to the UNL community through two poster symposiums attended by faculty, staff, and other students. The symposiums provided the interns a professional setting to communicate research accomplishments. Poster contests and recognition emphasized the priority for successful research accomplishment and communication in the REU program.

Interns also completed a science literacy project to summarize and synthesize their research and communicate it to a target audience. This process was integrated into the weekly TTS. Most interns selected the general public as their target audience and created science literacy products for this group. A few interns selected K-5 or K-12 audiences. Final products included written extension publications, infographics, recorded presentations, and videos.

Confidence in Research Skills, Likelihood of Graduate School, and Mentoring

Surveys were delivered online using SurveyMonkey® and participation was 100%. The pre-survey was administered online at the first TTS and included:

- Demographic information, expectations, and confidence in their research skills (Table 2).
- Questions as to how likely they were to pursue graduate education (Table 2).
- 24-item Mentoring Survey, worded exactly like Retallick and Pate (2009), on mentoring in general (Table 3).
- The post-survey was administered online at the last TTS and included:
    - Evaluation questions about their experience and change in confidence of their research skills.
    - Questions as to how likely they were to pursue graduate education.
    - 24-item Mentoring Survey, worded to be specific to their APS mentors (Table 3).

Both surveys included five questions about the interns' confidence in their research skills before and after the experience. The items were answered with a percentage, from 0% to 100% confident. The questions were written by the APS team. The three questions about the interns' likelihood of pursuing graduate education were written by the APS team. The interns answered these questions with a percentage, from 0% to 100% based on how likely they were to continue their education.

The mentoring questions in the survey from Retallick and Pate (2009) had three objectives:

- Record demographic characteristics;
- Determine the students' perceptions of mentoring effectiveness using a five-point Likert-style scale of agreement: 1=Strongly disagree, 2=Disagree, 3= Uncertain, 4=Agree, or 5-Strongly agree; and

Table 2.

Pre- and Post-Survey Research Skills and Graduate School Likelihood Questions Developed by Applied Plant Systems REU Team

Instructions	Items
Research Skills How confident do you feel in the following knowledge and skill areas? Answer with a percentage from 0% to 100%, but leave off the percent sign. For example, if you are 95% confident, enter 95. If you are 50% confident, enter 50.	1. Consider alternative hypotheses 2. Communicate your scientific ideas 3. Observe and interpret results 4. Statistical analysis 5. Being part of a research team
Graduate School Likelihood How likely is it that you will… (Please answer with a percentage from 0% to 100%, but leave off the percent sign.)	1. Apply to graduate school? 2. Succeed in graduate school if you apply and are admitted? 3. Apply to a graduate program related to your work in this summer program?

Table 3.

Mentoring Items Included in the Pre- and Post-Survey for the Applied Plant Systems REU Program

Pre-Survey Mentoring Items	Post-Survey Mentoring Items
1. A mentor is an information source.	My mentor was an information source.
2. Mentors play many roles.	My mentors played many roles.
3. A mentor demonstrates strategies for accomplishing goals.	My mentor demonstrated strategies for accomplishing goals
4. Mentoring is a process involving an exchange of information.	My mentor and I exchanged information.
5. A mentor observes student performance.	My mentor observed my performance sometimes.
6. Mentors should be active not passive.	My mentor was active not passive.
7. A mentor assists the student in developing a sense of professional identity.	My mentor helped me develop a sense of professional identity.
8. Mentoring is career development assistance.	My mentor gave me career development assistance.
9. Mentoring consists of frequent informal conferences.	My mentor and I had frequent informal conferences.
10. A mentor serves as an advocate for the student.	My mentor was an advocate for me.
11. Mentors demonstrate outstanding job skills.	My mentor demonstrated outstanding job skills.
12. Mentoring is a skill that requires training.	My mentor seemed to have adequate experience and training.
13. Mentoring is a socialization process.	Receiving mentoring was a socialization process for me.
14. Mentoring involves counseling a student.	My mentor gave me counseling.
15. The best mentors are directive in the process.	My mentor was directive in the process.
16. Mentors that are chosen are more effective than assigned mentors.	My mentor was effective.
17. Mentoring is a systematic process.	The mentoring was systematic.
18. Mentoring is a relationship between an older, more experienced person and a younger, inexperienced person.	Mentoring is a relationship between an older, more experienced person and a younger, inexperienced person.
19. A mentor is a role-specific model in the discipline.	My mentor was a role-model in the discipline.
20. Mentoring is based on friendship.	I thought of my mentor as a friend.
21. The student should lead the mentoring process.	I was allowed to lead the mentoring process.
22. Mentors have greater intellectual status than students.	My mentor has intellectual status.
23. Mentoring is the same as academic advising.	My mentor was like an academic adviser.
24. It is possible to mentor someone effectively on-line.	My mentor worked with me on-line quite effectively.

Note. Pre-items taken directly from Retallick and Pate (2009), post-items modified for APS project; a 25th item in the original Retallick and Pate, "Mentors give advice in a casual, laid-back way" was not included in the APS surveys.

- Determine the extent to which students rated the frequency of their mentoring based on a four-point Likert-style scale of frequency: 1=Never, 2=Sometimes, 3=Often, or 4=Always.

The current study used the same items for the pre-survey. However, instead of changing to a four-point frequency scale on the post-survey as Retallick and Pate (2009) did, we used a five-point scale of agreement from 1=Strongly disagree to 5=Strongly agree. We also modified post-item wording to relate to the interns' mentors in the APS program.

Statistical Analysis

The data files were analyzed using IBM Statistical Package for the Social Sciences (SPSS) Statistics Version 23 (2015). To compare pre- to post-survey results for the mentoring items, confidence in research skills, and likelihood of going to graduate school, we used SPSS Statistics Compare Means: Paired Samples T-Tests, always selecting the option of displaying ANOVA tables with two-tailed tests of significance. SPSS Correlate: Bivariate and asking for the Pearson's r coefficient of correlation was used to evaluate the linear relationship between pairs of items. Using SPSS Transform: Compute variable, new variables were created by calculating the difference between the pre-and post-survey means on each mentoring item. Then, the bivariate correlations between these differences were calculated. This gave the correlation between the amount of change on one item and the amount of change on another.

Results and Discussion

The APS experience, guided by mentoring, was intended to increase the opportunity for undergraduates interested in STEM to explore and advance toward a career as a professional in agriculture. Survey questions provided insights on all three elements of the tripartite integration model of social influence (TIMSI) which includes the concepts of science efficacy, identity, and community values (Estrada et al., 2018). Survey results provided insights on the three hypotheses posed on the impact of the APS internship and the mentoring the students experienced.

Hypothesis 1: Students will report a progression in confidence in their own research skills as a result of mentoring experiences.

Paired Samples T-Tests showed significant differences at the .05 level or better between the pre- and post-survey on all five research skills (Table 4). This shows the APS program was successful in increasing interns' confidence, even though some were quite confident about their skills when they began the program. This supports Hypothesis 1.

Hypothesis 2: Students will report mentoring experiences helped guide their educational and career pathways in agricultural STEM.

Using Paired Samples T-Tests, we looked at differences between pre- and post-surveys on these questions. Only the item on success in graduate school had a significant difference between pre- and post-survey (Table 5). The APS experience elevated their confidence in graduate school success, supporting Hypothesis 2.

Hypothesis 3: Student responses to mentoring approaches will vary and can guide mentoring improvement for faculty.

There were 10 items which had significant differences between pre- and post-survey at the .05 level or better (Table 6). More in-depth analysis of the ten significant items along with insightful student comments provided insights on how the interns responded to different mentoring tactics and structures. Hypothesis 3 was supported based on student responses to the mentoring items showing variation in response, with 10 items showing significant differences before and after the APS experience. Four correlations between mentoring items and research skills (Table 4) were also identified. Five bivariate correlations between mentoring items were significant at the .05 level or better (Table 6).

Mentoring Impact

The poster session at the end of the REU was a

Table 4.

Percent Pre- and Post-Mean Research Skills Confidence Rating for the 2017, 2018, and 2019 Applied Plant Systems REU Program

Survey items	Pre-survey mean	Post-survey mean	Difference between pre and post	Significant correlation with mentoring item**
Consider alternative hypotheses	66.52 (16.951)	82.43 (16.124)	.000*	
Communicate your scientific ideas	65.87 (19.966)	86.17 (9.013)	.000*	#12 [.530]
Observe and interpret results	69.87 (19.316)	85.00 (11.774)	.000*	#24 [.415]
Statistical analysis	50.65 (24.323)	75.00 (21.106)	.001*	#16 [.404] #23 [.511]
Being part of a research team	80.78 (3.396)	92.04 (10.891)	.002*	

Note. Numbers in parentheses are standard deviation of mean. Numbers in brackets are correlation values.
*Significant differences at .05 level or higher
**The Pearson's r coefficient of correlation was chosen because it can evaluate a linear relationship between two continuous variables.

Table 5.

Percent Pre- and Post-Mean Graduate School Likelihood Rating for the 2017, 2018, and 2019 Applied Plant Systems REU Program

Survey items	Pre-survey mean	Post-survey mean	Difference between pre and post
Apply to graduate school	85.65 (19.507)	85.22 (18.554)	.818
Succeed in graduate school if you apply and are admitted	86.43 (11.520)	92.96 (8.014)	.006*
Apply to a graduate program related to your work in this summer program	64.09 (24.413)	67.83 (28.277)	.472

Note. Numbers in parentheses are standard deviation of mean.
*Significant differences at .05 level or higher

Table 6.

Percent Pre- and Post-Mean, Significantly Different Mentoring Item Rating for the 2017, 2018, and 2019 Applied Plant Systems REU Program

Pre-Survey items wording	Pre-survey mean	Post-survey mean	Difference between pre and post	Correlation with other mentoring items **
1. A mentor is an information source.	4.22 (.795)	4.70 (.559)	0.013*	#16 [.398] #19 [.490]
12. Mentoring is a skill that requires training.	3.39 (1.033)	4.96 (.209)	0.000*	#17 [.632]
16. Mentors that are chosen are more effective than assigned mentors.	3.30 (.974)	4.57 (.590)	0.000*	
17. Mentoring is a systematic process.	2.83 (.887)	3.52 (1.163)	0.010*	
19. A mentor is a role-specific model in the discipline.	3.43 (.896)	4.65 (.487)	0.000*	
20. Mentoring is based on friendship.	3.39 (.783)	3.87 (1.015)	0.045*	
21. The student should lead the mentoring process.	2.65 (.885)	3.83 (.717)	0.000*	#20 [-.527]
22. Mentors have greater intellectual status than students.	3.26 (.752)	4.83 (.388)	0.000*	#23 [.522]
23. Mentoring is the same as academic advising.	2.17 (.778)	3.52 (1.082)	0.000*	
24. It is possible to mentor someone effectively on-line.	2.83 (.887)	3.74 (1.054)	0.002*	

Note. Numbers in parentheses are standard deviation of mean. Numbers in brackets are correlation values. Only the pre-survey wording is listed in this table to identify the survey mentoring item.
*Significant differences at .05 or higher
**The Pearson's r coefficient of correlation was chosen because it can evaluate a linear relationship between two continuous variables.

pinnacle and competitive event that tested the interns' science communication. In addition, the science literacy project involved collaborations with the TTS leaders. Students connected success with the poster and project with thoughtful and timely guidance. One student wrote that her mentor's help with her poster enabled her to develop professionalism. "My mentor gave really specific feedback on my poster draft that helped me bring my poster to a professional level."

The interns appreciated mentor thoughts on graduate school and occupations. One intern reported a long conversation with her mentor that was similar to what an academic advisor might have done. "My mentor and I sat down for 2.5 hours one day and just talked about my aspirations for the future and graduate school. She answered my questions and even made me consider taking a gap year or gap years, which is something I haven't completely considered before. All of her information of graduate school was very helpful."

A significant correlation was found between the research skill: "observe and interpret results" and the mentoring item, "It is possible to mentor someone effectively on-line." Online communication, especially email and text messaging, is a commonly accepted format for communication. Virtual meetings are a regular connecting point between students and teachers and other working groups. During the APS program some mentors were unable to daily meet face-to-face during the internship due to scheduling or travel. In these instances, online communication was used to organize the research team. Additionally, online communication was used by mentors to outline research tasks and provide feedback throughout the summer.

The interns came into the APS program with a high likelihood of applying to graduate school (85.65%). However, we can attribute their experience in the APS program with a significant increase in their self-perceived likelihood of succeeding once they are in a graduate program. Given that 14 of the 23 APS interns were undergraduates at non-research institutions, the opportunity to gain confidence was a significant accomplishment. The progression of the 23 interns in research skill confidence and their decisions about graduate school, demonstrate the success of the 10-week REU.

Mentoring Tactic Response and Tripartite Integration Model of Social Influence (TIMSI)

In addition to advancing research skills, STEM career progression likewise requires the student to envision themselves as a scientist and feel satisfaction in their role in the science community (Estrada et al., 2018). The significant change in the students' responses to many of the items in the mentoring survey, emphasizes how the decisions of the student's mentor influence the student's progress in science identity and community. It was clear that the students practiced science efficacy because the confidence in research skills increased after the APS experience (Table 4). Therefore, the discussion will focus on identity and community.

Identity

Significant positive change in seeing a mentor as a role model reflects the importance of identity in STEM career progress among our 23 interns. Faculty mentors or research lab leaders might give some thought to what traits or behaviors they want to model and how to proceed. One intern wrote that her mentor, "gave me advice on networking and getting as much experience as you can in your field. Do not be afraid to ask people questions and meet with people as this is crucial for building connections in your field and progressing your career."

One type of role modeling may relate to how errors and mistakes are handled. An intern working with a federal research lab wrote, "Everyone was very friendly and eager to teach me what I needed to know to be a useful addition to the lab. No one was angry about mistakes or shortcomings, and they gave helpful advice on how to fix and avoid similar problems in the future." Another intern wrote, "I was a little anxious that my experiments were not going well, and I remember my mentor mentioning that this is the nature of research and you are experiencing the true scientific research." These comments highlight the value of validating frustration, empathizing, and modeling the importance of learning from mistakes as mentors engage with students (Metcalfe, 2017; Weinzimmer & Esken, 2017).

This same intern mentioned that the TTS had made her more reflective. "Because it made me think about my week and reflect on what I had learned and what that means to me and to the public." Whether by the mentoring or the TTS, this intern had come to see reflection as characteristic of the role. Glenn, Esters and Retallick (2012) talk about the relationship between mentoring and reflection, referencing Kardash (2000).

> Undergraduates who have an opportunity to participate in research with a faculty mentor are able to take the theory that they have learned or read about and put it into practice, as well as to reflect on the positive and negative aspects of the experience. Through this process, students are able to 'do science,' which entails being able to understand a research problem and determining what is needed to address the problem (Kardash, 2000). (p. 36)

The 23 APS students were selected because they were academic leaders. However, as a group they reported significant advancement in the item, "The student should lead the mentoring process/I was allowed to lead the mentoring process." With hindsight, a better wording for the post-survey item might have been, "I was encouraged to lead" rather than "I was allowed to lead."

One intern commented directly on the leadership item. "My mentor gave great advice and feedback. She also assisted me throughout the whole research process but allowed me to lead and only assisted me when I struggled or asked for help."

Another intern wrote, "I remember my mentor would keep mentioning that I am the leader of this project and she would let me make decisions about my research. She would respect my opinions and gave me suggestions."

One intern felt too much of the leadership burden had been on her shoulders. "I think it would be really helpful to have structured time for learning from our mentors. My mentor was happy to help with what I asked of him, but I was always afraid to waste his time. I would appreciate being given feedback, being checked in on, or purposefully engaged with at least once in the summer when I didn't have to initiate it." This comment might also connect to the mentoring item about a systematic process and the perception that the mentor does or does not have a plan for the mentee.

These survey comments emphasize how mentors directly impact the experience and growth of their mentees. Fostering an environment where mentees are encouraged to learn, ask questions, contribute ideas and solutions, ask for help, take on leadership roles, and be a team-player encourages identity development where the mentee might see themselves as a scientist.

Community

Intern response to the pre- and post-survey item "Mentoring is based on friendship/I thought of my mentor as a friend" demonstrates the importance of community in STEM careers. Several interns commented on the friendly and helpful interactions with their mentor's team. One wrote, "My interaction with my mentor and the rest of my lab was very good. She was always available and willing to answer my questions and give me feedback on things. Everyone in my lab was helpful throughout the whole process and was always willing to help me in my study."

Friendship between mentor and mentee can be tricky in academia, as in many other settings, but it seems like the friendship dimension of mentoring was often operationalized through the mentors' research teams. An intern shared, "My interaction with my mentor and their teams were [sic] excellent. I had a really good experience with the support that they provided." Also, she said, "My graduate student had a great demeanor and was a wonderful person to talk to."

The research teams provided acceptance and helped the interns feel valued. One wrote, "Interaction with my mentor and their teams was easy. I was accepted into their group and sought help/assistance from all members. The team was easy to get along with and communication was well [sic]."

When the mentor was not as nurturing, the work group experience can compensate. If the research group does not compensate, the internship will not feel successful. One intern wrote, "I was grateful to spend a lot of time working with many different people in our lab team. Though working with such a large group was the hardest part of my work, the individuals themselves were also the best part of the work. They became a major component of my summer community. It was weird being here for such a short time though, some of them didn't really invest in getting to know me and many of them didn't know anything about the program I was with or what I was studying. I didn't have a grad student mentor and maybe that would have helped for giving me more direction with my study and analysis. My mentor didn't work with us, but he was really good at keeping up with communicating with us. I learned a lot from him about how to keep everyone on the same page and working effectively." Mentors may need to make more of an effort to prepare their research teams for the newcomers and remind them of their own experiences as a newcomer.

Several interns mentioned how much they enjoyed interacting with their fellow APS interns, often during the TTS. Only one said she did not feel especially comfortable with them (she did not elaborate). But she had good things to say about her mentor's research team. "I had positive interactions with my mentor and their team. They created an ecosystem in which I could thrive and really enjoy my experience in Nebraska on professional and personal levels." Her mentor has a history of making a particular effort to build a sense of community among their team.

Suggestions for New Mentoring Survey Items

Because the APS students varied in their backgrounds and prior research experience, it was anticipated that they would vary in their response to mentoring approaches. Measuring this response to guide mentoring improvement for faculty could be improved based on the analysis of the APS students. The mentoring items supplied by Retallick and Pate (2009) were developed for a program and university similar to the APS program, based on research about mentoring, and they provided a solid starting point. Given our data and interns' comments, we suggest eight additional items.

Perhaps the item on mentoring being systematic could be clarified by asking: "Mentors should have a plan for working with their mentees/My mentor had a plan for working with me." Rather than the item emphasizing informal meetings, it might be more meaningful to emphasize regularity of meetings. A better wording may be: "Mentors make themselves available to meet on a regular basis/My mentor met with me on a regular basis."

Attitudes toward mistakes were mentioned by several interns. There could be a survey item added which reads: "Mentors consider mistakes part of the learning process/My mentor considered mistakes part of the learning process."

Another useful item specific to research internships might be: "Mentors are passionate about research/My mentor was passionate about research." Networking is an important skill in any field. One intern's comment suggested an item to add: "Mentors give advice on networking in their fields/My mentor gave advice on networking."

The idea of encouraging mentees to be reflective practitioners is supported by research literature, for example, Boud (2001) and Boud and Walker (1998). Both articles suggest that reflection is vital for experiential learning. One of our interns mentioned reflection as an outcome of the TTS. A survey item like the following might be asked: "Mentors encourage reflection on what's being learned/My mentor encouraged me to reflect about what I was learning."

A good mentor needs to be able to offer guidance without telling the mentee how to do everything. Another possible item might be: "Mentors offer general guidance so we learn to work on our own/My mentor gave general guidance to help me learn to work on my own." On the other hand, sometimes more specific help is needed. Certainly, the interns appreciated specific suggestions for their posters.

Some learners have a greater need to follow their own interests to some extent because it is essential to their motivation and learning processes. A possible item might be: "Mentors encourage their mentees to incorporate their own interests into the research project if possible/My mentor encouraged me to incorporate my interests into the research project."

Reflection on the Connection of Mentoring Items

Since we had too few interns in the APS program to do a factor analysis, we calculated Pearson's r for pairs of items. Based on this calculation, we predict four factors among the correlated mentoring items (Table 6):

1. Mentoring is a teaching function that includes giving information and role modeling as well as effectiveness.
2. A trustworthiness or authority factor that includes intellectual status and advising as more of an institutional role rather than guiding student research work is valuable in mentoring.
3. Recognition that mentoring is a skill that requires training and experience as well as systematic effort.
4. There is an inverse relationship between student leadership and friendship connecting the importance of determining students' preferred approach to work (team vs. independent).

These four factors can guide mentoring practices. Glenn, Esters and Retallick (2012) wrote that their students said mentors should devote more attention to Clarity of Project, Training, Contact and Role Modeling functions. Some of our interns said they could have used more communication between the time they were accepted into the program and when they arrived on campus. They also mentioned needing clarity about deadlines. However, their reaction to the APS program as a whole and the mentoring they received was positive, whether their mentors were experienced or early career, working in an agriculture business, academics, or with a federal research lab.

Summary

Lessons learned from the three summers of the APS program can inform and guide a more intentional approach to mentoring which supports the blended research and education mission of a department, such as Agronomy and Horticulture, at a land grant institution.

It is important for undergraduates to be intentional about their role as a successful protégé (Fifolt and Searby, 2010). Based on the information we gathered from the APS interns, we believe that students need to:

1. Be aware of the science efficacy skills they are expected to learn and recognize when they are practicing them by conducting, analyzing, and communicating the research work.
2. Experience roles in a science community and appreciate the importance of transitioning between leadership and productive membership for the benefit of the community (team).
3. Explore their identity as a scientist. This exploration will require them to encounter both struggle and accomplishment. Reflection on how they feel about these moments will reveal the emotional connection between the science work and the self-satisfaction delivered from working and thinking like a scientist.

Faculty mentors are responsible for creating a research ecosystem which allows their protégés to progress in these three ways and document their progress. Mentors need to provide students the opportunity to:

1. Gain confidence in their science efficacy as a member of the research community. This confidence gain will combine training, self-calibration, and feedback for quality control and remedying mistakes. The protégé will extend their confidence through teaching and training others in the community. Mentors can support protégés by:
   a. Sharing research challenges, methods, and solutions based on personal experience
   b. Creating a space where failure is acceptable by sharing personal research mistakes, not just the successes
   c. Creating an environment of continual learning and growth by encouraging questions, creativity, and discussion
   d. Cultivating empathy toward the student and their experience
2. Accomplish leadership assignments which progress in the level of responsibility and their contribution to advancing the community toward their research goals. The mentor must expect and reward their protégé for the accounting of their research progress. Mentors can support protégés by:
   a. Encouraging mentee leadership on projects
   b. Creating a dynamic, inclusive team through collaborative projects, regular team meetings, peer-peer mentoring, and team social experiences to support all mentees
3. Reflect intentionally on their progress toward goals. This reflection should combine prompts from the mentor that are professional and personal so that the protégé can assess their current status as a scientist relative to where they started. Formulation of achievable future professional and personal goals will be critical if the undergraduate identifies themself as a career scientist. Mentors can support protégés by:
   a. Scheduling regular, individual meetings for mentor-mentee communication and feedback
   b. Communicating online or virtually; in-person meetings are also important
   c. Developing a mentoring plan with the student (revising when necessary) and use it; request student input on this plan to include what student expects
   d. Sharing personal experiences related to college education and/or career choice

References

Boud, D. & Walker, D. (1998). Promoting reflection in professional courses: the challenge of context. *Studies in Higher Education*, *23*(2), 191-206.

Boud, D. (2001). Using journal writing to enhance reflective practice. *New Directions for Adult and Continuing Education*, *90*(Summer), 9-17. John Wiley and Sons.

Estrada, M., Hernandez, P.R., & Schultz, P.W. (2018) A longitudinal study on how quality mentorship and research experience integrate underrepresented minorities into STEM careers. *CBE-Life Sciences Education*, *17*(1), 1-13.

Fifolt, M. & Searby, L. (2010) Mentoring in cooperative education and internships: preparing proteges for STEM professions. *Journal of Stem Education*, *11*(1&2), 17-26.

Glenn, M., Esters, L.T., & Retallick, M.S. (2012). Mentoring perceptions and experiences of minority students participating in summer research opportunity programs. *NACTA Journal*, *56*, 36-42.

IBM Statistical Package for the Social Sciences (SPSS) Statistics Version 23 (2015).

Kardash, C.M. (2000). Evaluation of an undergraduate experience: Perceptions of undergraduate interns and their faculty mentors. *Journal of Educational Psychology*, *92*(1), 191-201.

Metcalfe, J. (2017). Learning from Errors. *Annual Review of Psychology*, *68*, 465-489.

Potter, S. J., Abrams, E., Townson, L., & Williams, J. E. (2009). Mentoring Undergraduate Researchers: Faculty Mentors Perceptions Of The Challenges And Benefits Of The Research Relationship. *Journal of College Teaching & Learning (TLC)*, *6*(6). https://doi.org/10.19030/tlc.v6i6.1131

Retallick, M.S. & Pate, M.L. (2009). Undergraduate student mentoring: What do students think? *NACTA Journal*, *53*(1), 24-31.

Weinzimmer, L. G., & Esken, C. A. (2017). Learning From Mistakes: How Mistake Tolerance Positively Affects Organizational Learning and Performance. *The Journal of Applied Behavioral Science*, *53*(3), 322–348.