

ORIGINAL RESEARCH ARTICLE

Undergraduate Education

Implementing a species-specific undergraduate research program

Annie B. Lerner¹ | Mike D. Tokach¹ | Joel M. DeRouchey¹ | Jason C. Woodworth¹ | Steve S. Dritz²  | Robert D. Goodband¹ | Cassandra K. Jones¹ 

¹ Department of Animal Sciences and Industry, Kansas State University, 1424 Claflin Road, Manhattan, KS 66506, USA

² Department of Diagnostic Medicine/Pathobiology, College of Veterinary Medicine, Kansas State University, K-221 Mosier Hall, Manhattan, KS 66506, USA

Correspondence

Cassandra K. Jones, Department of Animal Sciences and Industry, Kansas State University, 1424 Claflin Road, Manhattan, KS 66506, USA.

Email: jonesc@ksu.edu

Abstract

Undergraduate research experiences have well-established benefits on undergraduate education, such as improved critical thinking, professional development, and increased interest in graduate studies. In addition, the host faculty can benefit by increasing their research impact and gaining exposure to potential graduate candidates. In the production animal science field (study of domestic livestock raised for meat, milk, or fiber), research also allows for additional livestock handling experience outside of the classroom, which is critical for students without agricultural backgrounds. At Kansas State University, the swine (*Sus scrofa domestica*) nutrition research group developed a swine-specific undergraduate research program. Several different models for projects are in place to maximize the research experience for students. Steps in the process include recruitment, initial student evaluation, project execution, presentation, evaluation, and post-graduate status update. There are several key roles in this training process. Graduate students serve as mentors and benefit from leadership training and development of interpersonal and managerial skills. Evidence collected after students have completed the program reiterates the importance of exposing students to not only the scientific method, but the swine and feed industries. Many of the students who complete projects ultimately pursue graduate or veterinary degrees, whereas those who choose nonresearch-related careers recognize the value of research and appreciate exposure to the swine industry. This case study will outline aspects of a swine-specific undergraduate research program, which can be applied to any life sciences discipline.

1 | INTRODUCTION

The advantages of undergraduate research are well-demonstrated throughout literature (Healey & Jenkins, 2009; Lopatto, 2004; Russell, Hancock, & McCullough, 2007). The benefits are multi-factored and exist for all

parties participating in the program. For the student, undergraduate research provides increased comprehension in the field of study, confidence, and desire to pursue graduate education (Russell et al., 2007). Additionally, critical thinking skills are improved, oral and written communication ability increases, and students develop professionally (Petrella & Jung, 2008). At Kansas State University (KSU), Jones and Lerner (2019) established

Abbreviations: KSU, Kansas State University; UGRP, undergraduate research program; UGRC, undergraduate research coordinator.

This is an open access article under the terms of the [Creative Commons Attribution-NonCommercial-NoDerivs](https://creativecommons.org/licenses/by-nc-nd/4.0/) License, which permits use and distribution in any medium, provided the original work is properly cited, the use is non-commercial and no modifications or adaptations are made.

© 2020 The Authors. *Natural Sciences Education* published by Wiley Periodicals, Inc. on behalf of American Society of Agronomy

that critical thinking gains are increased for students who complete undergraduate research compared with those that do not. The host program or faculty mentoring students are able to increase their research impact, whereas the university gains exposure via increased presentations and publications, and the ability to provide a more robust undergraduate experience (Petrella & Jung, 2008). Applied research also allows for hands-on, practical experiences in the field of study, especially, in the animal science curriculum, when increased numbers of students are originating from urban or suburban backgrounds (Harrison, 2015). This demographic shift makes hands-on activities with livestock, such as research or internships, increasingly critical in addition to traditional classroom training (Baranko, 2018; Sterle & Tyler, 2016). Furthermore, the swine industry, along with many other agricultural sectors, is facing significant challenges in finding, hiring, and retaining employees (Boessen, Artz, & Schulz, 2018); thus, it is important to expose students to opportunities within the swine industry during their undergraduate careers.

Faculty at many universities mentor undergraduate students and oversee research projects yet may not have an official program. Over time, the KSU applied swine nutrition team developed a formalized swine nutrition undergraduate research program (UGRP) that has allowed for an increased number of students to experience swine-based research and the swine industry, and also increased the number of research projects that can be completed. Previously, one to three undergraduate projects were completed per year. Yet, with the implementation of the new undergraduate research model, in addition to a course-based research class that provides 20 students access to a research project, 25 to 30 students complete swine-based projects each year. This case study will review the swine nutrition-specific research program that was developed at KSU, outline key characteristics that contribute to project and student success, and provide anecdotal evidence to support program efficacy. This concept and approach can be applied to any life-science discipline and provide similar student learning gains and program benefits.

2 | DEVELOPMENT OF A SPECIES-SPECIFIC UNDERGRADUATE RESEARCH PROGRAM

2.1 | Types of projects

One of three individual project models can be selected to provide the best experience for both the student and project mentor. Type of project is based on the undergraduate's talent, prior experience, and time availability. In coordination with the KSU Animal Science and Industry Undergraduate Research Program, students can earn varying lev-

Core Ideas

- Undergraduate research connects classroom concepts with industry skills in applied sciences.
- A discipline-specific, undergraduate research program increases students exposed to the discipline.
- Majority of students have gone on to enter graduate or professional school.
- This approach can be implemented in other animal science disciplines or other applied-science programs.

els of course credit based on project involvement. Aligning the swine nutrition UGRP with the departmental research program maximizes student experience and contributes to the departmental goal of increasing the number of undergraduate research experiences. Through this program, students completing projects can enroll in 0–3 hours of course credit, with 1 credit hour representing 45 hours of labor.

The first type of project is a shadow project. In this scenario, the student strictly shadows the graduate student mentor. Typically, this project is already designated as a part of the graduate student mentor's research program; thus, the undergraduate would not present these data as a stand-alone project. The student is expected to be at all chore activities and data collection days (i.e., pig weighing, sample collection, and feeding animals), but other pre- and post-trial activities (such as animal allotment, data entry and review, feed manufacturing, and writing of experimental results) may be up to the student's interest level or mentor's discretion. This type of project is ideal for students that are seeking their first experience with pigs, unsure about research, or not ready for additional responsibility. Depending on the student's time commitment, skill set, and interest, this project may count for course credit and be presented at the KSU Department of Animal Sciences and Industry Undergraduate Research Symposium but would not be presented at regional or national scientific meetings.

The next type of opportunity is an add-on project. In this experience, the student is responsible for helping with data collection, along with accompanying the graduate student mentor in the pre- and post-trial activities to increase learning opportunities and provide complete exposure to the research process. Oftentimes, this project may be an "add-on" to another research trial, where the graduate student mentor is already conducting an experiment, but additional response criteria can be collected to create an independent research trial for the undergraduate. In one example, a graduate student was conducting a sow feeding

trial evaluating sow and litter performance, while an undergraduate collected colostrum samples and had ownership in presenting these data. In another instance, the effect of nursery diets on nursery growth performance was being studied, and the undergraduate student presented fecal scoring data as it related to diet. These projects can be presented at departmental or college-level research forums and competitions, as well as regional or national scientific meetings. All students are asked to present at the departmental level. Additional presentations are decided based on student interest and capabilities and substance of the data set and criteria of various forums.

The final type of individual project model is a true independent project. The undergraduate is still supervised by a graduate student mentor, but the undergraduate is ultimately responsible for the project. This is an ideal UGRP type for projects funded specifically for an undergraduate (i.e., U.S. Pork Center of Excellence Swine Research and Education Experience grant). It is also independent in that it is not included in a graduate student's dissertation. This model is ideal for upper-class students, those who have already completed a shadow project, add-on project, or course-based research project, or graduate school candidates.

Another notable type of project, although not for individual students, is the course-based research project. In this model, approximately 20 students complete a swine research project within the bounds of a traditional semester class. The swine section is typically offered once per calendar year. The class is lecture- and lab-based, and the lab section consists of on-farm data collection for the experiment. This course began in the fall of 2017 and has significantly increased the number of swine-based undergraduate research projects. Additionally, it provides a mentorship opportunity for a graduate student to be a teaching assistant for the course and increases interaction with research faculty and students. Jones and Lerner (2019) provide further detail on implementing course-based research within the animal sciences and the efficacy of class projects compared with students who complete individual projects. Key findings from these data set demonstrate that there is no evidence for difference in critical thinking gains between course-based and stand-alone projects, but that participation in any type of undergraduate research provides improved critical thinking skills compared with students who do not complete a project.

2.2 | Roles of mentor and research coordinator

In the current undergraduate research model, there are two key graduate students involved in the training pro-

cess for undergraduate research (Table 1). The undergraduate research coordinator (UGRC) is the graduate student within the swine nutrition program that is responsible for assigning students to projects and mentors and overseeing completion of requirements. The graduate student mentor spends the most one-on-one time with the undergraduate student, and the project may be a part of this student's official research program work. The graduate student mentor in charge of the research project will act as the main advisor for the undergraduate student through the duration of the trial. During the trial, communication is most effective directly between these two parties, involving the UGRC and faculty when needed.

This model is similar to the apprenticeship model described by Hunter, Laursen, and Seymour (2007), except that the current program relies heavily on graduate students to complete a significant portion of the training process. The benefit of having these graduate student roles in the UGRP is multifaceted. First, it allows the responsibilities of project execution and day-to-day communication to be delegated between multiple parties. Secondly and most notably, it provides teaching and leadership experience for the mentor and the UGRC. Although graduate studies provide significant technical training in a given area of expertise, another important focus is development of interpersonal and leadership skills. Many graduate students enter the swine industry or academia, where they obtain leadership roles or are expected to mentor undergraduate students or other employees. Therefore, this experience in teaching an undergraduate, communicating, and project execution is invaluable. Oversight is, of course, provided by faculty members. This also provides the undergraduate with a very real-life taste of graduate school and increases interaction between the graduate student cohort and undergraduates, which is critical if the student is a potential graduate school candidate.

The UGRC was formerly responsible for mentoring all undergraduate projects. Utilizing other swine nutrition graduate students as mentors with oversight and coordination provided by the UGRC has allowed for an increase in the number of projects. It also delegates the onboarding process to several leaders and allows more students to gain experience in teaching and training.

2.3 | Recruitment and initial student evaluation

Identifying undergraduate students that will be a fit to the program can be one of the most significant challenges. The first step is getting word out about the UGRP. Advertisement is conducted in core undergraduate classes related to the discipline (principles of feeding, fundamentals of

TABLE 1 Role of undergraduate research coordinator and graduate student mentor

Undergraduate research coordinator
<ul style="list-style-type: none"> • Pair undergraduates with swine nutrition projects and arrange initial meeting of mentor and student to outline expectations and project details.
<ul style="list-style-type: none"> • Openly communicate with undergrad students, graduate students, and faculty, any approaches to improve the dynamics of the coordination process.
<ul style="list-style-type: none"> • Develop a mentor-student relationship ensuring a positive student experience while challenging students to commit to take a project from concept to completion.
<ul style="list-style-type: none"> • Stimulate the development of the student's skill set including decision making, stockmanship, and personal accountability.
<ul style="list-style-type: none"> • Provide support to the mentor, particularly in the preparation of the undergraduate abstract, poster, and presentation. The undergraduate research coordinator and faculty will be involved in the editing process as well as presentation preparation for each student.
Graduate student mentor
<ul style="list-style-type: none"> • Instruction on day-to-day research tasks.
<ul style="list-style-type: none"> • Fully describe the expectations of the student before the work event begins.
<ul style="list-style-type: none"> • Provide a robust learning experience by thoroughly explaining all processes completed for the project. Take advantage of any opportunity during work events to teach the student by both explanation and demonstration. Although timeliness and efficiency are key in most data collection events, they are secondary to teaching students in this scenario.

animal nutrition, swine science). Other opportunities for advertisement include clubs (swine-interest club), departmental or collegiate newsletters, and student welcome events. Also, many students are directed to the program through word of mouth. Typically, initial contact is made when the student makes an inquiry to swine faculty or graduate students.

Once student contact is initiated, an initial meeting between the UGRC and the student takes place. In this meeting, information gathered includes major, career goals, and reasons for interest in swine-related research. In addition, the student is provided information regarding the swine nutrition research group, including, but not limited to, core faculty, types of projects, and expectations of completing a research project. In this meeting, the UGRC must evaluate students for project readiness, which includes traits such as attention to detail, time management, communication, and relevant research, live-stock, and/or swine-related experiences. These traits can be demonstrated via resume and interview describing relevant experiences such as extra-curricular activities, work, and previous livestock ownership or care experiences. Students demonstrating these traits, as well as leadership abilities, desire to learn, and strong work ethic, are selected to participate in the UGRP.

2.4 | Onboarding

After the student is selected and paired with a mentor, several steps are taken to get the student onboarded and ready for the experiment. First, the student, mentor, and UGRC will review anticipated student learning outcomes (Table 2). Then, the undergraduate will complete required Occupational Health and Safety forms, Institutional Animal Care and Use Committee modules and quizzes, and a Domestic Animal Activity Liability Waiver. They are also provided with a complete list of graduate student and faculty contact information. Lastly, a contract (Table 3) is signed that outlines the anticipated time input for each aspect of the project, procedures for project termination upon second unexcused absence, animal welfare, or biosecurity issues.

When the undergraduate student first visits the KSU Swine Teaching and Research Center, they will be met by their mentor to walk through the biosecurity practices of entering a commercial swine farm. It is especially important to get students who lack pig experience comfortable with biosecurity steps to establish a good foundation and avoid any biosecurity breeches. This is also an example of how the program can provide real-life experience relevant to the commercial swine industry.

TABLE 2 Student learning outcomes

Treatment design and objective of the trial
Daily chores and the importance of good animal husbandry as it relates to data integrity
Data collection and how it relates to growth response criteria measured
Data review
Basics of data analysis (What statistical software was used? What types of comparisons were made between treatments? What is the significance level? What does a <i>P</i> value mean?)
Technical writing skills and scientific presentation style
Communicate the results to the swine industry and technical audience

TABLE 3 Undergraduate research student contract items

1.	Undergraduates that take on a project are expected to participate in <u>all events</u> related to the research trial that do not conflict with their class schedule.
2.	When you sign up for an event, you are expected to show up accordingly. It is your responsibility to know when and where you are to be for each event.
3.	If you cannot help after you have committed (strongly discouraged), you must provide a minimum of 24 hours notice to the graduate student in charge of the event. Failure to provide this notice or reoccurring absences will result in a warning and second occurrence will result in termination of student's involvement in the project and/or penalties to the final grade at the discretion of the graduate student mentors and faculty members.
4.	Grounds for immediate dismissal: A student's involvement in a project may be terminated at any time with the occurrence of the following events: <ul style="list-style-type: none"> • Animal cruelty or welfare problems • Breach of biosecurity • Second unexcused absence (first will receive a warning, second results in dismissal)

2.5 | Project execution

In all project types, undergraduates are expected to participate in daily chores and animal care along with the graduate student. Specifically, the undergraduate will visit the farm daily and evaluate feed/water status, health, and environmental quality. Although this is a large time commitment for students, it substantially increases student learning gains by providing livestock experience, understanding how data is impacted by daily decisions during chores, and cultivating a sense of responsibility to the trial. Previously, the student was allowed to decide whether they wanted to participate in farm activities beyond just weigh days. When given the choice, many decided to only attend weigh days, either due to interest level or time commitment. Over time, it was discovered that requiring participation in daily animal care increased the robustness of the project and student learning gains. It increased accountability of the student and allowed additional time for discussion with the mentor and learning about pig production.

Exposing the student to all areas of completing a research project (beyond just data collection) is a critical feature of this program and included for add-on and

independent projects. Activities completed during the pre-data collection phase in relation to swine nutrition include diet formulation, feed manufacturing, and allotment of pigs. In addition to being critical components of swine nutrition research, these activities increase exposure to swine production and may cultivate interest in the swine industry. Post-data collection activities include analyzing the data, examining outliers, and preparing abstracts and research presentations.

2.6 | Presenting the project

Presenting data to a scientific audience allows for broad application and thorough understanding of the research subject. In a review of undergraduate research literature, Linn, Palmer, Baranger, Gerard, and Stone (2015) reported that students are most often involved in project execution and not data interpretation. The KSU program seeks to deliver a wide-ranging experience, and thus, all students completing add-on or independent projects are encouraged to present research abstracts and posters at the Animal Science Research Forum each semester. This

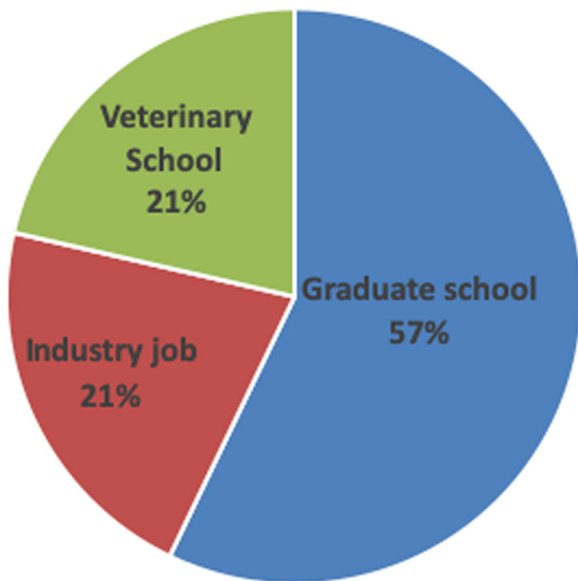


FIGURE 1 Post-project status updates for graduated students who completed undergraduate research. Ten students were asked to complete the survey, of which six responded

component can be as time consuming as completing the project because it is often the student's first exposure to scientific writing and statistics. However, preparing a presentation provides a well-rounded understanding of the data and application of the information.

The KSU Department of Animal Sciences and Industry Undergraduate Research Forum occurs each semester. Students who have completed independent or course-based projects have the opportunity to share their research in the form of poster presentations. It is judged by various faculty, and winners are awarded scholarships. Criteria for judging at this event include many of the aspects recognized at scientific meeting research competitions, such as abstract readability, poster organization, materials and methods clarity, communication of results, professionalism, rate of speech, and word choice. This benefits the undergraduate greatly as it may be the first time giving a scientific presentation. Students who complete shadow, add-on, and independent projects can present at this event.

If the student is presenting an add-on or a stand-alone project, it will typically be submitted for competition at Midwestern or National Meeting of the American Society of Animal Science. In addition to providing a peer-based competition to showcase their efforts, attending these scientific meetings also exposes students to animal science experts from around the country. At these meetings, they can connect with industry professionals and begin networking in their desired field. Presenting in this environment develops presentation skills and teaches students how to answer questions related to their project.

2.7 | Undergraduate student and mentor evaluation

Upon completing the project, both the student and mentor fill out surveys evaluating the other party. This is beneficial in providing feedback about any obstacles or areas for improvement. The mentors are asked to evaluate whether the student completed project requirements in a satisfactory manner and provide a letter grade if students are completing the project for credit. The undergraduates are asked to comment on the mentor's communication, helpfulness, preparation, and increasing their desire to learn about the subject. This information helps the UGRC understand how well students are paired with mentors and helps identify areas that can be improved in future projects.

2.8 | Evaluating the impact of a species-specific research program

It is challenging to quantify student learning gains and benefits. Jones and Lerner (2019) described methods for evaluating critical thinking pre- and post-project and demonstrated that critical thinking can improve with an independent research project. Although improved critical thinking skills are undoubtedly a desired outcome of the UGRP, we have sought to evaluate the impact of the UGRP from a swine industry perspective by collecting anecdotal evidence.

Approximately 1 year after this program was implemented, students who had conducted projects provided a "status update" and completed a survey on the undergraduate research program. Some students had already graduated, whereas others were still enrolled in undergraduate. Ten students were asked to complete the survey, and six responded, although three of these students had completed multiple projects. Out of the respondents, almost all (78%) students who had graduated were pursuing advanced degrees in either graduate or veterinary school (Figure 1). Areas of discipline include swine nutrition and feed science, both of which have direct impact on commercial swine production. Many students noted that completing undergraduate research was a relevant deciding factor in their desire to continue education and helped them select their field of study. This is similar to findings by Lopatto (2004), who described that 83% of survey participants planned to complete graduate studies. Furthermore, those who chose industry jobs acknowledged the value of undergraduate research and learned that graduate school was not in their current interest, which is a valuable finding for a young person when making career choices. Students acknowledged the opportunity to participate in research before committing to graduate school, connecting

TABLE 4 Responses from follow up survey for students who completed undergraduate research

“I am currently working at an Equine Hospital where I am able to use the problem-solving skills and other such skills, I learned during my research here in my job.”

“This helped me gain a greater understanding of the work that goes into and the process of research. I have been able to demonstrate my work ethics and knowledge to prospective employers as a result of completing an undergraduate research project.”

“My experiences helped me figure out I’m interested in a career in swine nutrition research, and also helped prepare me for an internship where I was able to apply and further expand on what I’d learned.”

“I think this is a great opportunity for students to really get a feel for research and see if this is a career or post graduate field that they would like to continue with.”

“I’ve gained a lot from working with my graduate student mentor and the undergraduate research coordinators I’ve interacted with; working with them helped to develop some of my first connections within the industry. I also had the chance to engage with my grad student mentor’s research beyond the trials I presented on, which helped broaden my research experience significantly, and he’s also someone I’ve been able to ask for advice as I’ve been working to figure out my plans for grad school and my future in general.”

with the swine industry, and benefits of one-on-one time with their mentor as strengths of the UGRP (Table 4).

3 | CONCLUSION

The development of a swine-specific UGRP has allowed the KSU applied swine nutrition team to increase contribution to undergraduate research goals of the department and university and seek out potential graduate school candidates. Students who have completed the program cite critical thinking, exposure to research practices, experience with pigs, and career selection as useful benefits of the program. Undergraduates who complete the projects regularly pursue graduate or veterinary school and often remain connected to the commercial swine industry. This approach can be applied to other animal science disciplines or applied science programs seeking to increase undergraduate research experiences.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

ORCID

Steve S. Dritz  <https://orcid.org/0000-0001-6371-0729>

Cassandra K. Jones  <https://orcid.org/0000-0002-0671-8879>

REFERENCES

- Baranko, L. (2018). The role of internship programs in undergraduate animal sciences education. *Journal of Animal Science*, 96, 250–251. <https://doi.org/10.1093/jas/sky073.463x>
- Boessen, C., Artz, G., & Schulz, L. (2018). *A baseline study of labor issues and trends in US pork production*. Urbandale, IA: National Pork Producers Council.
- Harrison, C. J. (2015). Integrating experiential learning into animal science curriculum through a hands-on beef cattle management

and marketing contest. (Master’s thesis, Illinois State University). Retrieved from <https://ir.library.illinoisstate.edu/cgi/viewcontent.cgi?article=1349&context=etd>

- Healey, M., & Jenkins, A. (2009). *Developing undergraduate research and inquiry*. York, UK: The Higher Education Academy.
- Hunter, A. B., Laursen, S. L., & Seymour, E. (2007). Becoming a scientist: The role of undergraduate research in students’ cognitive, personal, and professional development. *Science & Education*, 91, 36–74. <https://doi.org/10.1002/sce.20173>
- Jones, C. K., & Lerner, A. B. (2019). Implementing a course-based undergraduate research experience to grow the quantity and quality of undergraduate research in an animal science curriculum. *Journal of Animal Science*, 97(11), 4691–4697. <https://doi.org/10.1093/jas/skz319>
- Linn, M. C., Palmer, E., Baranger, A., Gerard, E., & Stone, E. (2015). Undergraduate research experiences: Impacts and opportunities. *Science*, 347, 1261757. <https://doi.org/10.1126/science.1261757>
- Lopatto, D. (2004). Survey of undergraduate research experiences (SURE): First findings. *Cell Biology Education*, 3, 270–277. <https://doi.org/10.1187/cbe.04-07-0045>
- Petrella, J. K., & Jung, A. P. (2008). Undergraduate research: Importance, benefits, and challenges. *International Journal of Exercise Science*, 1, 91–95.
- Russell, S. H., Hancock, M. P., & McCullough, J. (2007). Benefits of undergraduate research experiences. *Science*, 316, 548–549.
- Sterle, J., & Tyler, H. (2016). The next generation of animal science students: Changing demographics dictate curriculum changes. *Journal of Animal Science*, 94, 185–186. <https://doi.org/10.2527/msasas2016-396>

How to cite this article: Lerner AB, Tokach MD, DeRouchey JM, et al. Implementing a species-specific undergraduate research program. *Nat Sci Educ*. 2020;49:e20010. <https://doi.org/10.1002/nse2.20010>