

Educational and Extension Methods

Bringing Research to the Classroom: A Case Study of Course-Based Undergraduate Research Experience (CURE) in A Food Economy Class

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Abstract

This paper discusses the Course-based Undergraduate Research Experience (CURE) model and the development, implementation, and assessment of the CURE projects in a food economy course over four years, offered by the Department of Agricultural & Applied Economics at the University of Arizona. CURE involves whole classes of students in addressing a research question or problem that is of interest to stakeholders outside the classroom. Compared to traditional Undergraduate Research Experiences (URE), such as supervised independent studies or undergraduate research assistants in faculty projects, CURE makes scientific research more inclusive and presents a way to scale up the number of undergraduate students who engage in authentic research. The CURE project design closely followed the backward design principle and the five elements of the CURE framework: multiple scientific practices, collaboration, iteration, discovery, and broader impact. With the CURE model, students indicated increased research motivation, science identity, and communication and technical skills as social scientists compared to other course projects.

1. Introduction

In response to national calls to incorporate research experience into the undergraduate curriculum (AAAS 2011; NRC 2003), an increasing number of practices have been introduced to include undergraduate students in research projects. Traditionally, the integration of research into the undergraduate curriculum has primarily been in the forms of (1) research in faculty research labs, where undergraduates serve as paid research assistants; (2) research-focused independent study, where undergraduates earn credits through mostly one-on-one research experience; and (3) sponsored research experience (e.g., NSF Research Experiences for Undergraduate [REU], Research Experience and Mentoring [REM] sites, and USDA Research and Extension Experiential Learning [REEU] sites). The Course-based Undergraduate Research Experience (CURE) model involves whole classes of students in addressing a research question or problem of interest to stakeholders outside the classroom.

Both URE and CURE are communities of practice in which students engage in a variety of social and scientific activities and develop an understanding of scientific research practices (Krim et al. 2019). Engaging undergraduates in research experiences benefits students in several ways, including increased content knowledge, enhanced critical thinking, improved

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problem-solving skills in scientific contexts, and strengthened science identity (Jordan et al. 2014; Shaffer et al. 2014; Brownell et al. 2015; Rodenbusch et al. 2016; Bhatt et al. 2018; Gin et al. 2018). UREs, particularly during the academic year, also lead to increased interest and persistence in STEM, especially among underrepresented minorities (Lopatto 2004; Russell et al. 2007; Gregerman 2008; Hurtado et al. 2009; Estrada et al. 2011; Rodenbusch et al. 2016).

While traditional forms of URE benefit undergraduates in numerous ways, they are often accessible only to a select subset of students, predominantly from privileged backgrounds, indicating their limited accessibility (Dolan 2016; Ballen et al. 2017). The process often demands additional time from students to add research to their standard coursework. Faculties are incentivized to take the “best” students, and their implicit biases may advantage certain populations of students. The selection process and the hidden curriculum present additional barriers to underserved student groups.

The Course-based Undergraduate Research Experience (CURE) model improves diversity and makes scientific research more inclusive since students need only to enroll in a CURE course to engage in research. It expands research experiences to a larger scale of students and could be a way for every undergraduate to gain research experience (Ballen et al. 2017). This highlights the importance of equity in the scientific research community, as it fosters diverse perspectives, mitigates bias in scientific reasoning, and ensures the inclusion of the best minds, thereby expanding the pool of potential scientists (Bangera and Brownell 2014). Additionally, the traditional practice of UREs is carried out in a way where undergraduates follow a senior researcher (e.g., faculty, postdoc, graduate student), usually on a topic defined or led by that senior researcher (Auchincloss et al. 2014; Buchanan and Fisher 2022). CURE offers different types of opportunities for students to develop ownership of projects as they ask their own questions or analyze their own samples in response to an overarching research goal (Auchincloss et al. 2014).

The CURE model has been practiced in a variety of disciplines. The largest number of CURE projects have been in STEM majors—such as biology (67.8 percent of literature), chemistry (11.6 percent), and biochemistry (7.9 percent) (Buchanan and Fisher 2022)—but the social sciences have also adopted the CURE model. Ruangmas and Olson (2025) investigated a practice of CURE in empirical environmental economics for undergraduate students at the University of Maryland.

Our study investigates the development, implementation, and assessment of CURE projects in an undergraduate food economy course at the University of Arizona over four semesters since Fall 2020. Working with campus partners, these CURE projects aim to study college food insecurity and student food behavior at the University of Arizona. Assessment results are discussed

regarding students' perceptions of their knowledge level, skill comprehension, research motivation, and science identity. Further comments reflect the faculty experience, design considerations, resources, and incentives.

2. CURE Framework and Pedagogies

The CURE framework was developed during the meetings and discussions by the Course-Based Undergraduate Research Experiences Network (CUREnet), initiated in 2012. The term CURE was defined, and the results of the meetings were published by Auchincloss et al. (2014), who reported that the CURE framework is based on five elements and emphasized the integration of the five key elements in the learning process.

The five key elements identified include scientific practices, iteration, collaboration, discovery, and broader impact. The use of scientific practices exposes students to scientific research and offers them an opportunity to engage in the process of developing research questions, collecting data, designing tools and models, and carrying out/communicating findings. Traditional laboratory courses or methods are mostly instructor-driven, while CURE is student- or instructor-driven. Iteration stresses the importance of repeating or testing different methods to address an issue. Collaboration calls for students to improve their research outcomes and communication skills through the interaction of peer reviews. Discovery in the context of CURE indicates that students are able to address research questions by testing new theories or hypotheses. The process of scientific practices, iteration, collaboration, and discovery helps students better understand the research topic and develop their technical, analytical, and communication skills. In discovery, students build on their current research and extend the impact beyond the classroom. CURE offers students the opportunities to make novel findings (discovery) that have an impact beyond the course (broader impact and relevance) (Dolan 2016). The five elements are common activities and not unique to the CURE framework. Integrating all five elements into a scalable course setting makes the CURE learning experience different from a traditional laboratory course, inquiry laboratory course, or a research internship (Auchincloss et al. 2014).

CURE pedagogies combine the learning of scientific investigation from inquiry-based instruction and the authenticity of experiential learning. Both inquiry-based instruction and CURE aim to develop students' research skills in project-oriented learning that reflects scientific investigation (e.g., students do the work that scientists do). The CURE model is distinguished from inquiry courses in that it offers students opportunities to make discoveries that are of interest to stakeholders outside the classroom (Auchincloss et al. 2014). Both experiential learning and CURE motivate student learning through authenticity and the relevance of the learning experience. CURE focuses on authentic research experience, while experiential learning projects can take various forms with community partners, such as service learning.

3. CURE in a Food Economy Course

In this section, we discuss the development, implementation, and assessment of CURE projects in an undergraduate food economy course at the University of Arizona.

3.1. Course Overview and Description

Few questions are more fundamental than how we feed the world's people. Yet the coexistence of food insecurity and food waste begs the question: How can we feed the population efficiently, sustainably, and equitably? The idea of a food course to shed light on some grand challenges in our food economy was seeded in the “Big Ideas Interdisciplinary Thinking” Faculty Learning Community at the University of Arizona in Spring 2019. Guided by the Experiential Learning Design Accelerator program and CURE Training Institute at the University of Arizona, a food economy course was designed, proposed, and launched in Fall 2020. This course familiarizes students with the food economy and its efficiencies while identifying where gaps occur as food flows from producers to consumers. These gaps frequently lead to food insecurity with a less healthy population, as well as food waste. By examining (1) the food supply chain and markets, (2) food insecurity, (3) food loss and waste along the food supply chain, and (4) food policies through the lens of marginalized populations, students gain insights into the economic forces that shape the food system.

The undergraduate research experience is carried out through the course project. The research project connects students with relevant and authentic food challenges in local communities and guides students in analyzing and researching, leading to student-driven discoveries and solutions. The overarching research questions are related to food and human behavior, but the specific project topic and objective could vary from one semester to another, depending on community partners' focus when the course is taught.

The food economy course is designed as a general education course to encourage students from diverse academic backgrounds to collaborate and engage in research experience. It has been offered in fall semesters since 2020, and the course size varies from 25 to 80 (Table 1). Enrolled students are from various majors; most are freshman and sophomore students, and about one-third are first-generation students (Table 1). Ishiyama (2002) has shown that participating in early UREs in social sciences and humanities leads to significant gains in analytical and critical thinking skills among first- and second-year students, especially for first-generation students.

In addition, the food economy course takes a multidisciplinary approach and had been cotaught by instructors from the Department of Agricultural & Applied Economics (AAE) and the School of Nutritional Sciences & Wellness at the University of Arizona. Each instructor lectures and demonstrates perspective-taking (e.g., ways of thinking, methodologies, and tools) as

Table 1. Course and student characteristics

Semester	Modality	Enrollment Number	Number of Distinct Majors	Percentage of Freshmen and Sophomores	Percentage of First Generation
Fall 2020	Synchronous online due to COVID-19	32	21	55.9%	37.5%
Fall 2021	In-person	25	12	56.0%	36.0%
Fall 2022	In-person	63	38	73.0%	30.2%
Fall 2023	In-person	80	43	77.6%	30.0%

economists and nutritional scientists in addressing food system issues. Both instructors are present in all class sessions and model interdisciplinary dialogue in the classroom.

3.2. CURE Design

In this section, we discuss the CURE design in detail on learning and research objectives, objective–activity–assessment alignments, assessment results and challenges, limitations, and opportunities for design considerations.

3.2.1. Learning and Research Objectives

The research experience in the undergraduate general education course follows the Backward Design approach. We first define course learning objectives, align assessment with objectives, and design the research and learning activities of the course (Wiggins and McTighe 1998). In CURE, the course objectives merge the students' or pedagogical goals with the research goals. Despite more than a decade of studies in nutrition, economics, and public health, food insecurity among US college/university students remains a pervasive problem within higher education (Landry et al. 2024). While the average prevalence rates of 33–51 percent were reported for food insecurity among college students in recent literature, emerging research suggests that the existing food insecurity measurement tools may not accurately contextualize the experiences of college students and the campus food environment (Ellison et al. 2021 and Landry et al. 2024). The overarching research goals for this CURE are to identify and characterize college student food insecurity, food environment, and food behavior. The specific research project objectives are summarized in Table 2, which vary depending on the needs of the community partners from semester to semester.

Following the CURE outcomes reviewed by Corwin et al. (2015), the course aims to advance student skills in scientific thinking, research, and collaboration. More specifically, the learning outcomes are to (1) increase student content knowledge of food insecurity and survey methodology, (2) increase student competency in quantitative reasoning, such as analytical and technical skills of working with quantitative information, (3) improve student oral and written communication skills, and (4) advance student collaboration skills in the scientific process.

Table 2. Research objectives and partners in CURE projects

Semester	Research Objective	Community Partners
Fall 2020	Assess food insecurity among UA students before and since the COVID-19 pandemic	• University Office of Assessment and Research • University Campus Pantry
Fall 2021	Investigate food environment and behavior among student residents on the UA campus	• University Housing & Residential Life
Fall 2022	Investigate cultural food accessibility and food insecurity among international students on the UA campus	• The Basic Needs Coalition at UA • University Office of Assessment and Research
Fall 2023	Assess food insecurity and service feedback among UA campus pantry users in 2022/23	• University Campus Pantry and Campus Closet

3.2.2. Objective–Activities–Assessment Alignment

The CURE project and learning are designed following the CURE framework of five key elements: multiple scientific practices, collaboration, iteration, discovery, and broad impact. The project design starts with brainstorming sessions between the instructor and campus partners to ensure the authenticity and broad relevance of the project beyond the classroom. Each summer before the fall offering, campus partners and the instructor discuss and negotiate an area or theme to balance the partner's needs and feasibility as a CURE project in a semester-long course. Since the first offering in Fall 2020, the course has worked with various campus partners to understand college student food insecurity, student food behaviors, campus food environment, and cultural food accessibility and affordability (Table 2).

The semester-long CURE project is scaffolded with various project tasks corresponding to the CURE element of multiple scientific practices (Table 3). An extensive project document is assigned to students the first week of class, detailing project objectives, project learning outcomes, background, project tasks, project division of labor, project calendar, rubrics for project presentations and written report, peer evaluation, tips for success, and common mistakes. The class starts to engage with the campus partners and research topics early in the first two weeks of classes. For example, the director of the Campus Pantry presents in the class and introduces college student food insecurity, especially as it relates to the campus community. The class would also visit the Campus Pantry and Campus Closet to gain firsthand experience. The Campus Pantry director highlights the issue and needs, then charges the class with the specific questions to address for the CURE project. The setup provides students with authentic and tangible project information, aiming to stimulate interests, motivate research, and aid the hypothesis writing at the beginning of the semester.

Throughout the semester, students work through a complete scientific research process, from defining research questions and hypotheses, writing a literature review, designing a survey, collecting data, conducting data analysis, to reporting results. Survey methodology is used in all projects. Within the

Table 3. Example of the project tasks and calendar table for the CURE project, Fall 2023

Project Task	Group Responsibilities	Due Date	Points
(1) Assign project	Grouping and match section topics	Monday, 9/4, 11:59 PM	10
(2) Define the questions	Task deliverables	Monday, 9/11, 11:59 PM	20
(3) Literature review	Task deliverables	Monday, 9/25, 11:59 PM	40
(4) Survey design	Task deliverables	Monday, 10/9, 11:59 PM	40
(5) Data collection			40
(5.1) Sampling plan	Group 1–7	Monday, 10/23, 11:59 PM	
(5.2) Qualtrics survey setup	Group 8–14	Monday, 10/23, 11:59 PM	
(5.3) Distribution plan	Group 15–20	Monday, 10/23, 11:59 PM	
(6) Data analysis	Task deliverables	Monday, 12/4, 11:59 PM	40
(7.1) Written report	Individual assignment	Monday, 12/11, 11:59 PM	100
(7.2) Report presentation	Group presentation	12/13, Wednesday, 1-3 pm	80
Total points			370

overarching theme of the research goal in each semester, the surveys are made up of four to five subsections, with topics such as general food access, student food behavior and expenditure, transportation & housing, cultural food at the University of Arizona, campus pantry services, and demographic information. The subsections of each survey project offer students options to dive into one area of interest and carry out the topic throughout the semester. The instructor teaches and guides the students in specific scientific practices during project skill lectures, which are carried out parallel to the project's progress. About five project skill lectures are included with topics on defining research questions, literature review, survey design, survey sampling, distribution, Institutional Review Board (IRB), and data analysis and visualization. Community partners, such as colleagues from the Campus Pantry, were invited back to the class again through multiple scientific practices, such as providing feedback to students designed survey questionnaire mid-semester (more discussion below on the iteration aspect) and serving as judges when students present their findings at the end of the semester. The increased content knowledge, technical and analytical skills, along with the continuous student engagement with project partners, could further contribute to students' increased self-efficacy and motivation in science (Corwin et al. 2015).

Collaborations among students, teaching assistants, and instructors take place both in and outside the classrooms. The CURE project is designed as a group project where students work in groups throughout the semester, for two reasons: First, the CURE model recognizes science as a team effort and that collaboration is essential. It improves students' communication skills and research outcomes through peer interactions and peer review opportunities. In addition, increased communication and collaboration skills could also contribute as pathways to students' increased sense of belonging to a larger community, further increasing student tolerance for obstacles and strengthening external validation from a science community (Corwin et al. 2015). Second, as class size increases, group design keeps project implementation manageable.

The best practices of CURE suggest keeping group size small, with two to three students, to enhance peer learning and mitigate free riding issues. Balancing class size with best practice, we assign students to groups of three to four students at the beginning of the semester. With 56–77 percent of the class being freshmen and sophomores (Table 1), we make sure at least one senior or junior student was grouped with each freshman and sophomore to stimulate effective peer learning. We also spread out the Honors students in different groups in another effort to balance group qualities. During each project skill lecture, group workshop time is designed, and students work in groups to apply the scientific skills to their specific project. The class has been taught in a Collaborative Learning Space (CLS) in the University of Arizona, where the classroom is set as tables of four students facing each other with small whiteboards, markers, and erasers to facilitate collaborative learning activities. The course was designed to be active and engaging, and the CLS classroom setting enhanced group collaborations significantly. Students continue collaborating with peers outside of class time. In addition, the teaching assistants offered additional office hours dedicated to project tasks and group collaborations.

The CURE model also recognizes that risks of “messy” data are inherent; therefore, iteration is built into the process. In our CURE project, the survey design goes through several iterations. Student groups first draft their survey questions, focusing on their research questions and literature review. Students revise and resubmit based on the instructors’ initial feedback. The instructors then combine all resubmitted student survey questions into one file. Depending on the class size, three to five groups would work on the same subsection of the survey, and they would gather and negotiate to revise and consolidate questions in each subsection during a class lecture. As a result, the first draft of the class survey is completed and organized in a shared document. In a specific class lecture, students would present their survey design, section by section, to campus partners. Partners provide direct feedback to students in class and comment on the shared document. The second draft of the class survey is completed with students’ revisions incorporating partners’ comments and suggestions. Finally, the class survey is tested in class and among students’ friends and peers. During this process, students practice iterations in the scientific process that increase project ownership, potentially leading to increased self-efficacy and motivation in science (Corwin et al. 2015).

Students present their discoveries as an infographic and a written report. Campus partners are invited to these presentations to further engage with students and provide feedback. The CURE projects have generated novel findings about food insecurity and student food behaviors in the UA student population, which have shown a broader impact in the campus community. In the Fall 2020 project, students documented the significant increase in food insecurity at UA amid the COVID-19 pandemic. The results were reported by the Daily Wildcat, the UA student news site, in April 2021 (McCarville 2021).

The students' project also provided primary data for the UA Hispanic Serving Institution (HSI) Faculty Seed Grant project "Food Insecurity Among College Students: Understanding Hunger at the University of Arizona," in 2023/24. A policy report, *Cultural Food on the University of Arizona Campus 2022*, was generated based on the Fall 2022 CURE project. The results were presented and/or shared with campus stakeholders, including the Campus Pantry and Campus Closet, the Basic Needs Coalition, the International Student Services, and the UA Graduate College. The CURE project findings also contributed to changes in the Campus Pantry services, such as adding ethnic food sourcing due to the limited cultural food access on campus. Making discoveries and contributing to broader impacts could increase project ownership and student self-efficacy. Ultimately, it stimulates increased motivation in science and enhances science identity (Corwin et al. 2015). Table 4 summarizes the project design and further maps them with the CURE framework and outcomes.

3.3. Learning Assessment

We assess student learning in CURE using a retrospective pretest survey. In the last class sessions in Fall 2021, 2022, and 2023, students were asked on their demographic information and to evaluate seven statements on a 5-point scale from 1–5 (1 being strongly agree and 5 being strongly disagree) before and after taking the food economy class. The seven statements are summarized in Table 5 with the learning outcomes they are intended to measure.

Based on the assessment framework discussed in Corwin et al. (2015) and additional empirical literature on CURE, the seven statements were designed and adopted to capture the possible learning outcomes achieved from CURE, such as increased motivation in science, improved communication, collaboration, analytical and/or technical skills, increased self-efficacy, and enhanced science identity (Brownell et al. 2015; Cooper et al. 2020; Werth et al. 2022; Wilczek et al. 2022).

Table 6 provides a detailed breakdown of key demographic variables for students who enrolled in the food economy course during the fall semesters of 2021, 2022, and 2023 as well as their proportional representation relative to the total enrollment within each demographic category. Freshmen constituted the highest average proportion, accounting for approximately 46.0 percent. White students formed the predominant group, consistently comprising over two-thirds of the cohort each year. Both Asian American and African American students, although fewer, represented substantial proportions. In contrast, Native American and other racial categories were minimally represented. Academically, most students maintained a GPA above 3.0, while a segment of the group had GPAs ranging from 2.0 to 3.0.

In terms of research experience, most students had not engaged in paid research previously, with only about 9.6 percent of the sample possessing any related experience. We asked student research experience via course project with two prompts:

Table 4. CURE framework, outcomes, and course activities

CURE Framework (Auchincloss et al. 2014)	CURE Outcomes (Corwin et al. 2015)	Course Activities Employed
Multiple scientific practices	Short-term outcomes: Increased content knowledge, analytical & technical skills, and communication skills Long-term outcomes: increased self-efficacy & increased motivation in science	Students work through a complete scientific research process, with scaffolding and tasks of the semester-long CURE project
Collaboration among students, teaching assistants, and the instructor in a course	Short-term outcomes: increased collaboration skills and sense of belonging to a larger community Long-term outcomes: increased tolerance for obstacles & external validation from a science community	The instructor guides the students in specific project skill lectures Students work in groups in and outside of class TA offers additional office hours on facilitating project tasks
Iteration Risks of generating “messy” data are inherent. Iteration is built into the process	Short-term outcomes: increased project ownership Long-term outcomes: increased motivation in science & increased self-efficacy	Iterations in survey design, from group questions to combined project survey, then finalize with community partner feedback Iterations in data analysis
Discovery The purpose is defined by student or instructor The outcome is unknown Findings are novel	Short-term outcomes: increased project ownership and analytical skills Long-term outcomes: increased self-efficacy & increased motivation in science	The overarching purpose of the investigation is informed by the campus partners; group research questions are defined by students Novel findings of food insecurity and student food behavior on UA campus
Broad Impact/Relevance The relevance of students’ work extends beyond the course Students’ work often presents opportunities for action	Short-term outcomes: increased communication skills, project ownership, and sense of belonging to a larger community Long-term outcomes: increased motivation in science & enhanced science identity	Infographic as required project products Food insecurity status at UA amid the pandemic in 2020, reported by the Daily Wildcat Primary data support for a Faculty Seed Grant Policy Report of “Cultural Food on the UA Campus 2022”

Table 5. Survey measurements

Survey Statements	Learning Outcomes Measured
“I am motivated in research.”	Increased project ownership and motivation in science
“I think like a social scientist.”	Increased self-efficacy
“I communicate like a social scientist.”	Increased communication skills and enhanced science identity
“I am using tools of social scientists better.”	Increased analytical skills and enhanced science identity
“I think scientific research is a team effort.”	Increased collaboration skills and enhanced science identity
“I like group projects.”	Increased collaboration skills
“I like research projects.”	Increased motivation in science and enhanced science identity

1. “This class required you to work on scientific research project throughout the semester. How common were these kinds of projects in your other college classes?”
2. (2) “This class required you to work on an *authentic* scientific research project where you interact and partner with community partners such as the campus pantry. How common were these kinds of projects in your other college classes?”

In our sample, about 39.4 percent of students reported that a research project was very or somewhat common, while the rate was 29.1 percent for the authentic research project like the CURE project. The majority, 70.8 percent of the students sampled reported that the authentic research project is mostly uncommon or rare. On one hand, research projects were still mostly

uncommon among sample students, with even fewer authentic research projects. On the other hand, the CURE model had been promoted and supported since 2020 in UA through an annual CURE Training Institute, training and facilitating faculty with new CURE course proposals. Thirty-four CURE courses have been designed from 2020 to 2024, and 16 were offered in the 2023–2024 academic year. This comprehensive demographic and educational profile provide valuable insights into the diversity and academic experiences of the student body over the specified timeframe.

Table 7 shows the sample average ratings for the seven statements before and after taking the CURE class, the difference in average ratings resulting from the CURE experience, and the p -value statistics for testing the hypothesis that there is no difference in the average ratings before and after the CURE experience. The average ratings vary annually, but certain patterns emerge. Notably, the 3-year average ratings for all categories prior to CURE exceed 2.5 except for “I think scientific research is team efforts.” This suggests that, initially, students tended to disagree with the statements. After the CURE experience, all ratings decreased, with the majority falling below 2.5. The drop is also reflected in the difference in mean perceptions before and after CURE. A negative number means that students’ ratings decreased after the experience, suggesting that students held stronger beliefs of agreement on the statements subsequently. As discussed in Corwin et al. (2015), the differences in ratings reflect short-term outcomes resulting from CURE experience. We further tested the difference in mean perceptions and present the p -value results in the last section of Table 7. Most of the tests are significant in rejecting the null hypothesis except for “I like group projects” in all years, “I am motivated in research” in years 2021 and 2023, and “I like research projects” in year 2023.

3.4. Finding 1: Students Indicated That They Were More Motivated in Research and Showed Enhanced Science Identities

We found that students agree more on the two statements “I am motivated in research” and “I like research projects” after their experience. We further tested the significance of the differences. The 3-year average results are both significant (at the 5 percent level for the first statement and 10 percent for the second statement). However, we discover year-to-year fluctuations. The first statement, “I am motivated in research,” is only significant (5 percent) in the students’ results in 2022; the second statement, “I like research projects,” is significant in 2021 (10 percent) and in 2022 (10 percent). The increased class size in 2023 might contribute to the insignificant differences that appeared for the 2023 cohort.

In addition, we examined students’ perceptions regarding collaboration using the two statements “I think scientific research is team efforts” and “I like group projects.” Regarding “I think scientific research is team efforts,” students in the class displayed a deeper understanding of scientific research as a collaborative endeavor. This is supported by the differences in ratings and

Table 6. Summary of key demographic variables

Variable	Number of Students				Proportions (%)			
	2021 Fall	2022 Fall	2023 Fall	Entire Sample	2021 Fall	2022 Fall	2023 Fall	Entire Sample
Sample size	20	45	62	127		Response Rate (%)		
Class enrollment	25	63	80	168	80.0	71.4	77.5	75.6
Year in school								
Freshman	7	29	22	58	35.0	65.9	35.5	46.0
Sophomore	2	7	22	31	10.0	15.9	35.5	24.6
Junior	5	5	9	19	25.0	11.4	14.5	15.1
Senior	6	3	9	18	30.0	6.8	14.5	14.3
Race/ethnicity								
Native American	1	0	2	3	5.0	0.0	3.4	2.5
Asian American	1	6	8	15	5.0	14.0	13.6	12.3
African American	3	2	3	8	15.0	4.7	5.1	6.6
White	14	29	45	88	70.0	67.4	76.3	72.1
Other	1	6	1	8	5.0	14.0	1.7	6.6
Self-identified gender								
Female	11	19	39	69	55.0	43.2	62.9	54.8
Male	9	24	22	55	45.0	54.5	35.5	43.7
Non-binary	0	1	1	2	0.0	2.3	1.6	1.6
Cumulative GPA								
<2	0	0	1	1	0.0	0.0	1.6	0.8
2.0–2.5	2	1	2	5	10.0	2.4	3.2	4.0
2.6–3.0	5	6	13	24	25.0	14.3	21.0	19.4
>3.0	13	35	46	94	65.0	83.3	74.2	75.8
Prior paid research experience								
None	15	42	56	113	75.0	95.5	91.8	90.4
< 12 months	4	1	4	9	20.0	2.3	6.6	7.2
≥ 12 months	1	1	1	3	5.0	2.3	1.6	2.4
Are research projects common in your prior classes								
Very common	1	1	7	9	5.0	2.2	11.3	7.1
Somewhat common	11	9	21	41	55.0	20.0	33.9	32.3
Mostly uncommon	4	18	17	39	20.0	40.0	27.4	30.7
Rare	4	17	17	38	20.0	37.8	27.4	29.9
Are authentic research projects common in your prior classes								
Very common	1	0	3	4	5.0	0.0	4.8	3.1
Somewhat common	7	7	19	33	35.0	15.6	30.6	26.0
Mostly uncommon	4	10	14	28	20.0	22.2	22.6	22.0
Rare	8	28	26	62	40.0	62.2	41.9	48.8

Notes: Some students did not answer some questions.

Table 7. Changes in student perceptions associated with CURE: *t*-tests

	I Am Motivated in Research	I Think Like a Social Scientist	I Communicate Like a Social Scientist	I Am Using Tools of Social Scientist Better	I Think Scientific Research Is a Team Effort	I Like Group Projects	I Like Research Projects
Sample average of perceptions before CURE is taken							
2021 Fall	2.50	2.85	2.95	2.85	2.15	2.80	2.50
2022 Fall	2.62	2.91	3.04	3.00	1.96	2.96	2.79
2023 Fall	2.50	2.79	2.89	2.68	2.26	2.92	2.73
All years	2.54	2.84	2.95	2.82	2.13	2.91	2.72
Sample average of perceptions after CURE is taken							
2021 Fall	2.05	1.85	2.30	2.05	1.60	2.95	2.10
2022 Fall	2.27	2.40	2.47	2.20	1.67	2.73	2.42
2023 Fall	2.39	2.42	2.40	2.18	1.90	2.85	2.70
All years	2.29	2.32	2.41	2.17	1.77	2.83	2.50
Difference in mean perceptions before and after CURE							
2021 Fall	-0.45	-1.00***	-0.65**	-0.80***	-0.55**	0.15	-0.40*
2022 Fall	-0.36**	-0.51***	-0.58***	-0.80***	-0.29**	-0.22	-0.37*
2023 Fall	-0.11	-0.37***	-0.48***	-0.50***	-0.35**	-0.06	-0.03
All years	-0.25**	-0.52***	-0.54***	-0.65***	-0.36***	-0.09	-0.21*

Notes: Perceptions are measured on a 1–5 scale, with 1 indicating strongly agree. Single, double, and triple asterisks indicate statistical significance at the 10 percent, 5 percent, and 1 percent level, respectively.

the significance levels of the *p*-values. The results of the four statements show evidence that students showed enhanced science identities through the CURE experience. However, we do not find significant test results for the statement "I like group projects." This could be potentially driven by the various challenges in project management with student group work, especially as the class size increases. We discuss those challenges in more detail in Section 3.6.

3.5. Finding 2: Students Showed a Deeper Understanding of Thinking as Social Scientists. Students Showed Improvement in Their Ability to Communicate and to Use the Tools of Social Scientists

Our study revealed a notable enhancement in students' understanding of thinking like a social scientist when comparing their pre- and post-course responses to the statement "I think like a social scientist." We observed negative differences and 1 percent significance levels across all years. Furthermore, we designed two statements to test if students perceived ability needed to be social scientists has been improved. The two statements are "I communicate like a social scientist" and "I am using the tools of social scientists better." Table 6 shows that the before and after differences are all negative numbers and that the 3-year average significance levels across the three years are significant

at 1 percent level. Most of the significance levels are significant at 1 percent except for the result in 2021 to the statement "I communicate like a social scientist," significant at 5 percent level. The results suggested that students had increased their communication, analytical, and/or technical skills and had therefore increased their perceived self-efficacy.

3.6. Challenges, Limitations, and Opportunities

The Course-based Undergraduate Research Experience (CURE) model, while highly beneficial and inclusive, will require significant efforts in design and implementation. Several challenges and limitations are discussed here for design considerations.

First, the CURE projects that engage community partners like ours require a lengthy planning and co-creation process. Negotiation happens among the partners' needs, student learning, and research goals. Budget significant lead time in developing partnerships and co-creating the CURE project ahead of the course offering. To supply diverse research ideas for CURE, it is helpful to be flexible about research topics under an overarching research goal. For example, the topic of student food security was a priority with the onset of COVID-19 in 2020, and the research theme of assessing student food insecurity was carried out. Yet given the many existing student surveys on schedule on campus, an annual survey on student food insecurity facilitated by the university office was not feasible. After a trusting partnership developed, community partners can propose more ideas and research needs and new relationships can be built with new research focus, including research on the food environment among student residents in collaboration with the university housing office and cultural food accessibility and affordability, focusing on the international student services. To actively connect students with partners, it is good practice to design multiple touchpoints with stakeholders throughout the semester, such as class talks, mid-point project feedback, and end-of-semester project presentations. Alternatively, CURE model could also be implemented in faculty-led research labs, mostly in STEM majors, where the class dives into a few scientific practices of an existing research project over one semester.

Another set of challenges lies in project management. With enrollment increasing to 80 students in the CURE course, managing project progress and student group dynamics become more and more challenging. First, to coordinate research experience, the project is designed so that student groups can work in parallel with the scientific research process while being autonomous in research questions among different groups. Subsections of survey questionnaires offer students opportunities for diverse research focuses under one overarching research goal. The general subsections were set up with community partners before the semester and presented to the students along with the project assignment at the beginning of the semester. For STEM majors, student groups may work with different varieties while following the

same procedure. (e.g., practice the genome reading process with different varieties of tomatoes). This helps accommodate larger class sizes and provides diverse research experiences that foster peer learning. At the data collection stage in our CURE project, student groups need to work in parallel on three different project tasks—such as sampling plan, distribution plan, and Qualtrics survey setup—to move the project forward as a class. Though students did not practice all three aspects of data collection, all skills are introduced and discussed in class. Students also practice research collaboration firsthand in this setting.

Second, we need to redesign the final presentation format as the class enrollment grows. When the class size is under 80 students with fewer than 20 groups, each student group presented their project orally during the 120 minutes of scheduled final exam time. In Fall 2024, when there were 87 students with more than 20 groups, we pivoted to a poster forum in the classroom. Student infographics were cost-effectively printed as paper posters. With the best infographic voting activity and group coordination, the whole class turned into a poster forum where students, instructors, and community partner judges walked around and interacted with each other. Finally, the graduate teaching assistant (TA) is critical in project management, providing significant peer mentorship and facilitating project management. For example, trivial bonus incentives were provided for student groups to meet with the TA and discuss project tasks before submission.

One remaining challenge is the free-riding issue with student group work. The whole CURE project is a group assignment and counts for 37 percent of the overall grades, with the remaining 63 percent as individual assignments. Despite the intentional grouping practice to balance student experience (e.g., match upperclassmen with underclassmen and pair honors students with nonhonors students, free-riding issues persist in few groups every semester, unsurprisingly. We incorporate peer evaluations of group work to instill individual accountability. The grades of the project can be adjusted based on the peer evaluation results. Additionally, allocating more class time to build team norms and relations could be helpful. Overall, the increased class size posed additional challenges in student group work. The best practices in CURE design suggest a small group size of two to three students, in which students collaborate productively while the likelihood of free riding is reduced. In order to balance in-group dynamics and across-group coordination, students were in groups of four to five in the studied CURE courses. The challenges in collaborating with a larger group in a large class could contribute to students' perceptions of group work and research projects in CURE. In our results, we do not find significantly different responses towards the statement "I like group projects" before and after taking the CURE course. The differences in responses towards the statement "I like research projects" were also insignificant in 2023, the largest class size during the study periods.

Furthermore, setbacks and changes in the research project add additional challenges to project management in the CURE classroom. In Fall 2021, the CURE project was planned and carried out with a focus on the student resident population, collaborating with the University Housing & Residential Life. Yet the Housing office changed its survey calendar from the fall semester to the following spring, which disrupted the data collection plan in CURE. Though frustrating, the setbacks are usually great teaching moments for students to learn the trial-and-error process of authentic research.

Finally, the CURE model is a tall order to carry out in a 16-week semester, especially at scale. Instructors need to balance various student learning objectives and be realistic about the research objectives. In our case, students learn and apply survey design, sampling, and distribution. However, only about 2 weeks of classes were left after the survey data were collected. Students continue the data analytic part with descriptive statistics and basic charting in Excel. Multiple efforts have been taken to carry out these research projects in depth. For example, an additional internal grant was secured and two research assistants, one undergraduate and one graduate student, were hired in spring and summer 2023 to continue learning from the data collected by the CURE projects. One report regarding campus cultural food was generated and presented to campus partners, and one manuscript is in submission for journal publications. Another approach in completing the research cycle is to design two or more sequential CURE courses where each CURE carries out different stages of a complete research project. Ruangmas and Olson (2025) have documented a sequential CURE program in empirical environmental economics at the University of Maryland. Faculty incentives also play a significant role here. The CURE model seems to be an excellent fit for faculty with Research and Teaching splits in their FTE. There are CURE co-teaching examples where a Research faculty member paired with a Teaching faculty member to run a CURE course in STEM.

4. Conclusions

The Course-based Undergraduate Research Experience (CURE) model engages a whole class of students to address a research question or problem that is of interest to stakeholders outside the classroom. Compared to traditional Undergraduate Research Experience (URE), such as supervised independent studies or undergraduate research assistants in faculty projects, CURE makes scientific research more inclusive. In traditional URE, only a subset of students can participate, and those who participate tend to be from more privileged backgrounds. CURE removes barriers when students only need to enroll in a CURE course to engage in research. Thus, CURE presents a model to scale up the number of undergraduate students participating in authentic research.

This article discusses the development, implementation, and assessment of the CURE projects that study college student food insecurity and food behavior in a food economy course. In four semesters, 200 students of diverse

majors, mainly freshmen and sophomores, have engaged in CURE, and more than 50 infographic reports have been presented to campus partners such as Campus Pantry & Campus Closet, the Basic Needs Coalition, the International Student Services, and the UA Graduate College. With the CURE model, students indicated increased motivation in research, increased science identity, and increased communication and technical skills as social scientists, compared to other course projects. By design, these CURE projects also led to novel discoveries and broader impacts. The student-driven CURE results were cited in a community news outlet, contributed to improving the Campus Pantry services, and provided primary data for a faculty seed grant award.

CURE provides a great model to align research and teaching programs and shows great potential in agricultural and applied economics, in our opinion. Our CURE case in a food economy course can be extended to cover other food-related topics, such as food waste, food deserts, food swamps, food miles, food preferences, and food behaviors. Similar to the food theme, many grand challenges that our profession contributes to addressing, such as water issues, climate adaptations, and economic development, to name a few, all show deep roots in local communities, thus presenting precious opportunities for students to engage firsthand. The CURE model empowers all students with research skills to be part of solutions. It is our hope that CURE will be of broad interest to agricultural and applied economists, especially those who seek to align their research and teaching programs as well as those who strive to make the undergraduate research experience more inclusive.

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AI Disclosure

Nothing to report.

Human Subjects Disclosure

Research here adheres to pertinent policies and regulations at the federal, state, and university levels for data involving human subjects. The University of Arizona Institutional Review Board approved the research protocol (IRB No. 1904566916).

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