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Understanding the Experiences of First-Generation College Students in CUREs through Written Reflections

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Abstract: Course-based Undergraduate Research Experiences (CUREs) have the potential to lower barriers to participation in research for a wide range of undergraduate students. In this study, we examined written reflections of first-generation college students who participated in CUREs to understand the challenges and benefits that these courses offered them.

Keywords: *Quality Enhancement Plan, STEM, Qualitative Methods*

Introduction

Course-Based Undergraduate Research Experiences

To promote greater exposure to authentic research among undergraduate students, undergraduate research experiences (UREs) have been introduced in higher education institutions (Olsen and Riordan, 2012). However, the typical URE structure limits research opportunity accessibility. On the other hand, Course-Based Undergraduate Research Experiences (CUREs) are an alternative approach that offers more scalable and accessible research experiences to undergraduate students because they occur within the context of a credit-bearing course. In this study, we examined written reflections of first-generation college students who participated in CUREs to understand the challenges and benefits that these courses offered them.

CUREs involve an entire class addressing a research question with unknown outcomes that may lead to novel discoveries and original research. Unlike undergraduate research experiences where students are engaged with an established research project led by a faculty member, CUREs allow all academically eligible students to enroll, regardless of past research experience. In these courses, students create their own hypotheses and research designs, collect and analyze data, and write up and share their own work.

CUREs are defined by curricula that engage students in five key areas (Auchincloss et al., 2014):

- Novel Discovery: students engage in research work in which the outcome is unknown, leading to the creation of new knowledge.
- Research-Based Practices: students identify research questions, propose hypotheses, design experiments, collect, analyze and interpret data, and find applications for their work.

- Broadly Relevant: students engage in research projects that have a wide scope that allows them to influence the field outside of their class.
- Collaborative: students engage in group work, peer review, and discussions that lead to new solutions to research problems.
- Iterative: students undertake a repetitive process in which they review the results of their research and then revise their work to address emergent problems and limitations.

Research has found that students who participate in CUREs demonstrate positive outcomes similar to the gains observed in students engaged in independent undergraduate research, including greater interest and self-confidence toward science (Brownell & Tanner, 2012). Further, CUREs increase inclusion and participation in science by strengthening students' awareness of undergraduate research and the cultural norms of science, as well as providing more frequent interactions with faculty (Bangera & Brownell, 2014; Corwin, Graham, & Dolan, 2015). These experiences may be particularly impactful for underrepresented students (Hernandez, Schultz, Estrada, Woodcock, & Chance, 2013).

First-Generation College Students

While there is evidence that CUREs may increase access to undergraduate research opportunities for underrepresented students and promote academic outcomes similar to more selective URE efforts, less is known about the personal experience of CUREs for students from underrepresented groups. Studies have noted that there is limited information on first-generation college students' participation in UREs, but these studies did not address CURE courses specifically, where - presumably - first-generation college students would be more likely to enroll (Carpi and Lents, 2013; Ishiyama, 2007; Kwong Caputo, 2013; National Academies of Science, 2017; Stephens et al., 2014; Van Soom and Donche, 2014).

CUREs at the University of North Carolina at Chapel Hill

At UNC-Chapel Hill, we have built a program to expand CURE courses across the sciences, social sciences, and arts and humanities. A leading doctoral university, the University of North Carolina at Chapel Hill has used its Quality Enhancement Plan (QEP) to create more opportunities to promote greater dialogue among faculty about assessment of student learning and to situate assessment of student learning as a faculty-driven initiative. A Southern Association of Colleges and Schools Commission on Colleges (SACSCOC) reaccreditation requirement, the QEP is specified as "focusing on an issue that the institution considers important to improving student learning outcomes and/or student success" (SACSCOC, 2020, 1). As a distinguished research university, UNC-Chapel Hill identified providing meaningful research experiences for undergraduates as an institutional priority, and the QEP and its subsequent assessment has been central to the realization of this priority. By incorporating many of the findings and insights from the QEP initiative into the new General Education curriculum, not only has the QEP been sustained, but undergraduate education at UNC has been transformed.

An aim of the QEP is to increase the inclusion and diversity of the university's research community by creating more opportunities for authentic research experiences for all students. Quantitative data suggests that CUREs are providing these opportunities, especially for students who have been historically underrepresented in undergraduate research. For example, in the fall of 2019, when this study was conducted, the first-generation students comprised nearly 18.7% of undergraduate enrollment, but only 15.1% of mentored research students. In contrast, nearly 20% of students enrolled in CUREs were first-generation students.

However, while metrics such as these suggest that access is improving, we have little insight into students' personal experiences with CUREs and whether or not these experiences have impacted their sense of inclusion in the university's research community. To address this question, we examined students' open-ended reflections about their experiences as students in CURE courses.

Population Description
Data used in this study included survey responses from 696 students from a random sample of 17 undergraduate CURE courses. These courses included 11 disciplines, of which seven were in natural science and four were in social science disciplines. Table 1 summarizes the number of courses in the sample, organized by discipline, as well as the number of participants and the proportion of participants who identified as first-generation.

Table 1
Description of CURE courses used in analysis

Discipline	Number of courses	Number of participants	Percentage of first-generation Participants
Anthropology	1	15	20.0%
Biology	2	41	24.4%
Chemistry	3	259	17.4%
Computer Science	1	14	21.4%
Ecology	1	13	46.2%
Exercise and Sports Science	1	27	7.4%
Geography	1	12	8.3%
Geology	1	20	25.0%
Political Science	1	18	16.7%
Psychology	4	224	19.2%
Public Policy	1	53	18.9%

Qualitative Data

For qualitative data collection, we utilized two open-ended questions in post-course surveys from CURE courses. These open-ended questions asked, "Based on your research experiences in this course, what would you describe as one of the (or the) most rewarding experiences?" and "Based on your experiences in this course, what would you describe as your most challenging experience?". We analyzed the responses to these questions from students who took CURE courses during the Fall 2019 semester.

After post-course survey responses were collected and reports generated, qualitative responses were added to NVivo12 Qualitative Data Analysis software for the purposes of coding and analysis. Coding is an essential part of survey research, and open-ended qualitative response coding is no exception. One key difference between the coding of qualitative (open) and quantitative (closed) survey questions is that qualitative coding is a process done by the researcher after the data has been collected, whereas quantitative coding is accomplished by the survey respondent as set up in the survey design prior to administration (Fielding, Fielding, & Hughes 2013).

The deductive coding process starts with the creation of a codebook of codes (i.e., themes) for categorizing and analyzing the qualitative responses. The codebook for this study was developed a priori, adapting previously identified constructs for the "Creating Scientists" QEP (Fielding, Fielding, & Hughes, 2013; Bernard, 2011; Fereday & Muir-Cochrane, 2006). Since CURE courses seek to engage a class in an introduction to research through a hypothesis-driven research problem, the codes that were initially developed followed this initiative. We used the following 13 codes to categorically describe open-ended responses from students in the post-surveys: analyzing data, calculations, interpreting results, community analysis and feedback, lack of clear instruction, little experience, unclear purpose, research methods, gathering data, curiosity and discovery, testing ideas, long-term outcomes, and contribution. Each code had a strict definition that provided structure and consistency for the qualitative analysis (Bernard, 2011; Fereday & Muir-Cochrane, 2006).

After the creation of the codebook (see Table 2), we used a word frequency calculator and text searching in NVivo12 to find segments of texts that aligned with the language of the defined codes (Fielding, Fielding, & Hughes, 2013). Following this, the researchers reviewed the NVivo results of all post-course qualitative survey items for CURE courses in Fall 2019, and then coded the appropriate responses that fit the code we were seeking to match at the time. We considered the same response against each of the 13 codes in the codebook until exhausting the codebook. "An advantage is that such an approach may be more transparently rooted in the data and less prone to researcher bias than wholly manual coding" (Fielding, Fielding, & Hughes 2013, p. 11). We then went through each individual CURE post-course survey report to look for uncoded responses. Any uncoded responses were considered against the codebook and coded as appropriate. If there was not an a priori code whose definition fit the sentiment or assumed meaning of the response, then a memo was made for the response. Once the a priori, or deductive, coding was complete, the memos were reviewed to identify any emergent (i.e. inductive) themes that were prominent in the data (Gavin 2013; Fielding, Fielding, & Hughes, 2013; Fereday & Muir-Cochrane, 2006).

In a similar fashion to Fereday & Muir-Cochrane (2006), a combination of deductive and inductive coding was then implemented to account for nuanced or emergent themes that were prominent in the data but not accounted for in the initial codebook. Coding in qualitative research is “often seen as an iterative process, with ideas and themes being drawn from interpretations of some of the data, refined in the context of inspecting further data, and then applied to all of the data” (Fielding, Fielding, & Hughes 2013, 10). As a best practice, this iterative process is aimed at narrowing down interpretations to encapsulate the manifold sentiments and phenomena present in textual data.

Consequently, some definitions of codes for CURE courses were modified to account for both broader or more precise themes as the analysis progressed (Fielding, Fielding, & Hughes 2013). There was one emergent theme that resulted from this process of coding text: research process. This theme was identified as prominent due to its recurrence in several student responses from different courses. After the theme was identified, it was defined according to its expression among the various segments of text and added to the codebook. This new code was defined as “Mention by a student of perceived challenge or reward encountered through the process of research, itself. Can include mentions of time management, organization, scope of research project, and other procedural difficulties or rewarding elements. Also includes mentions of finishing or completing the project.” Inductive, or emergent, codes “are not objects but expressions of a phenomenological experience and therefore the process of discovering them cannot be wholly explicit” (Gavin 2013, 279).

During the process of applying a code to a segment of text, in this case one full student response to a single open-ended question, there was a possibility of the co-occurrence of codes. This occurred when a single unit of text could be coded into multiple categories based on the content of the text. Additionally, each segment of text was coded for whether it was a “challenge” or “reward” for the respondent, depending on which of the open-ended questions the respondent was answering at the time. On very few occasions, responses were not coded beyond “reward” or “challenge” due to the lack of substance in the text or poor fit with the codes. As such units of text were seldom encountered in the data, they did not warrant the creation of an emergent code.

With any codebook or qualitative coding, it is important to test the accuracy and reliability of the codes (Fielding, Fielding, & Hughes 2013). There are various ways to test the reliability of codes, but generally, “the analyst needs to be confident that each application of the code is closely equivalent in meaning, and that no other responses have been omitted from that code despite carrying an equivalent meaning” (Fielding, Fielding, & Hughes 2013, 14). For this study, as we used NVivo12, the software package already allowed for the first test of consistency, as it “readily list[s] all of the passages that share a particular code” (Fielding, Fielding, & Hughes 2013, 14). The second step of testing code reliability involved perusing the list of responses aligned with each code, as organized in NVivo, and re-referencing the segment of text against the final codebook. During this process, some responses were re-coded into a different category and others were removed from a category that did not appear to be the best fit.

Table 2
CURE Course Qualitative Codebook

Qualitative Code	Definition
Analyzing Data	Where students made mention of experiencing effects positive or negative as a result of analyzing data for the CURE course.
Calculations	Where students made mention of experiencing effects positive or negative as a result of calculating data for the CURE course. Includes mentions of "synthesis" of aspects of the project or materials. Includes mentions of making a product and running tests.
Interpreting Results	Where students make mention of perceived positive or negative effect of interpreting results of research, understanding the results/data, or of drawing conclusions from the data.
Challenge	Use in combination with other codes, or individually, to code any response to the question, "What was the most challenging aspect of the course?"
Community Analysis and Feedback	Where a student mentions having had a positive or negative experience from communicating findings to their classmates, instructors, clients, or others outside of the scope of the project. Includes mention of writing or drafting reports or discussing scientific or research issues with other individuals (whether students, faculty, or non-UNC persons), as well as mentions of working as a team to analyze findings or advance the project.
Contribution	Mention by a student of a perceived reward of having made a contribution through the project to a greater cause, knowledge base, their field, or the world.
Curiosity and Discovery	Mention by students of a perceived reward from satisfying one's curiosity through the research process and reward with having made discoveries. Includes mentions of "seeing

	results.'' Differs from “Unclear Purpose” code in that students do not have to mention the unclear purpose of the project having made an impact on their experience.
Gathering Data	Where a student mentions perceived positive or negative experience with gathering data for their CURE course project.
Lack of Clear Instruction	A mention by a student of perceived challenge due to the lack of clear instruction or guidance by the course instructor.
Little Experience	Where a student makes mention of a perceived challenge or reward due to little experience with the format, course material, or type of work. Can also include for mention of the nuance of the course materials or research methods, themselves, that pose difficulty or present reward.
Long-term Outcome	Where students mention perceived challenge or reward of the expected or unintended long-term outcomes of the project for their CURE course. Can include for building knowledge, satisfying curiosity, solving everyday problems, informing policy, developing technology, and/or addressing social issues.
Research Methods	Where students mention perceived positive or negative impact of nuanced methods for researching, to include for navigating literature reviews.
Research Process	Mention by a student of perceived challenge or reward encountered through the process of research, itself. Can include mentions of time management, organization, scope of research project, and other procedural difficulties or rewarding elements. Also includes mentions of finishing or completing the project.
Reward	Use in combination with other codes, or individually, to code any response to the question, "What was the most rewarding aspect of the course?"

Testing Ideas	Mention by a student of perceived positive or negative experience with the steps of the research process, involving creating a hypothesis and collecting either supportive, contradictory, surprising, or inconclusive data in relationship to said hypothesis; to add for mentions of "performing an experiment" and for "answering the research question," both of which include hypothesis testing; also add for challenges or rewards encountered with project design.
Unclear Purpose	Mention by a student of perceived challenge or reward due to unclear purpose of the research project or methods. Also includes language admitting a lack of understanding of the instructor's expectations for the purpose of the project. A rewarding mention is one in which a student mentions excitement due to discovery in this area.

With NVivo12 software, there are features that allow a qualitative researcher to visualize the coded data for a more robust interpretation of the data. While the software can show code frequencies and code co-occurrences across themes and groups, it can also show word clouds, tables, and cross-tabulation. In order to further interpret the qualitative data, attribute, or demographic, data was uploaded into NVivo and respondent identity markers were added to the responses. In doing so, we were able to generate statistical outputs in NVivo12 to show how sentiments toward CURE courses were distributed across student demographics. Particularly, our team focused on the demographic, “first-generation student status.”

Findings

Part of the goal of the Quality Enhancement Plan was to increase the access to these curricular research programs for underrepresented student demographics. Through the course of research, we paid special attention to the access story for first generation college students participating in CURE (Course-based Undergraduate Research Experience) courses. In the following section, we demonstrate how first-generation students appeared more receptive to the construct of Discovery than their continuing-generation peers, as evidenced by the quantitative results and exemplified with open-ended data.
Upon review of the open-ended survey responses, we found that first-generation students participating in a CURE course were roughly one and a half times (1.46 times) more likely to comment on a positive aspect of having discovered something about research through the course of their project. When asked, “based on your research experiences in this course, what would you describe as one of the (or the) most rewarding experiences?” in a CURE course, 41% of first-generation students (n = 47) made mention of an aspect of curiosity and discovery, whereas 28% of continuing-generation students responded similarly. Comments coded for “curiosity and discovery” were those that fit the

following description: "Mention by students of a perceived reward from satisfying one's curiosity through the research process and reward with having made discoveries. Students do not have to mention the unclear purpose of the project having made an impact on their experience. Includes mentions of 'seeing results'". The number of comments in each code category by first-generation (FG) and continuing-generation (CG) status are provided in Table 3 below.

Table 3

Summary of Qualitative Coding by Course Discipline

Course	Analyzing Data	Analyzing Data\Calculations	Analyzing Data\Interpreting Results	Challenge	Community Analysis and Feedback	Contribution	Curiosity and Discovery	Gathering Data	Lack of Clear Instruction	Little Experience	Long-Term Outcomes	Research Methods	Research Methods\Research Process	Reward	Testing Ideas	Unclear Purpose	TOTAL Themes (unique)
Anthropology - FG	0	0	0	3	1	2	2	3	0	0	3	3	2	3	1	0	3
Anthropology - CG	2	0	1	12	8	1	2	9	1	2	2	8	3	12	4	1	12
Biology- FG	2	1	4	10	6	1	4	1	1	1	0	1	1	10	5	1	10
Biology- CG	3	1	5	31	21	2	16	2	0	1	7	6	10	31	21	2	31
Psychology - FG	4	1	4	13	10	1	3	0	0	2	2	4	3	13	7	0	13
Psychology - CG	9	1	6	48	39	5	12	2	0	12	6	16	17	48	24	1	48
Chemistry - FG	4	4	1	12	6	0	8	1	0	3	0	1	3	12	5	2	12
Chemistry - CG	19	27	30	93	32	3	35	13	15	16	11	22	18	87	52	18	93
Computer Science - FG	0	0	0	3	2	0	2	0	0	0	0	1	0	3	2	0	3
Computer Science - CG	0	1	0	11	5	2	3	0	1	2	5	4	6	11	3	0	11
Ecology - FG	1	1	1	5	2	1	2	3	0	1	0	3	1	5	4	0	5
Ecology - CG	1	0	0	7	3	2	1	5	0	3	3	0	0	7	2	0	7
Exercise Science - FG	0	0	1	2	0	0	1	0	0	0	0	0	1	2	2	0	2
Exercise Science - CG	4	1	6	22	12	1	5	3	0	4	0	3	4	22	17	1	23
Geography - FG	0	0	1	1	0	0	1	0	0	1	0	0	0	1	1	0	1
Geography - CG	4	0	9	11	4	1	5	1	1	6	1	3	0	11	1	0	11
Geology - FG	2	1	4	5	2	0	1	1	0	1	1	1	1	5	1	0	5
Geology - CG	5	0	5	15	12	1	8	1	0	4	1	3	4	15	10	0	15
Public Policy - FG	0	0	0	5	5	1	1	1	0	1	3	3	4	5	1	0	5
Public Policy - CG	6	2	1	42	30	16	10	5	1	3	15	21	33	41	14	3	42
Political Science - FG	1	0	1	3	1	1	2	1	0	1	0	2	0	3	2	0	3
Political Science - CG	2	2	0	13	6	0	2	3	0	3	1	6	4	13	6	0	13
TOTAL Code Applications	69	43	80	367	207	41	125	55	20	67	61	111	115	360	185	29	368

Examples of excerpts from first-generation college students coded for "curiosity and discovery" include statements such as, "The most rewarding part of the project was finally being able to connect everything together and understand the bigger picture," and "Doing all the parts on our own was rewarding, because we actually got to experience the real process of research." Note, although the definition for this theme denotes the mention of curiosity or discovery being part of a rewarding mention, it was still possible for a student's response to the question about their greatest challenge in the course to include an aspect of reward through discovery. Examples include statements such as the following:

> "Working in a group has been challenging because not everyone is equally motivated to work, though that's almost always the case with group projects. This class has prompted me to

> explore ideas of race and justice in ways I've never had to do before, and I feel like I've learned and grown a lot because of it."

Some comments acknowledged the difficulty students perceive when conducting laboratory experiments in a traditional setting, and how such difficulty was not a factor for an experiment in a CURE course. One student said, "Actually, doing the experimental work, I learned patience and it was nice to do something that was practically brand new. It took pressure off the students to do the experiment 'correctly'." Another student remarked, "Collecting my own data was the most rewarding because I felt that I had more of an individual role in the research experiment. I was able to better understand what I was doing and why I was doing something in the experiments."

First-generation students in non-laboratory-based CURE courses also had mentions of curiosity or discovery being a rewarding part of their experience. One such student doing archival and interview research commented, "Being able to find traces of people's lives from a hundred years ago was rewarding because it felt like we were recovering people's stories and existence, one record at a time." Another first-generation student doing computer-based research wrote that the most rewarding part of the CURE course project was "completing the development of an app that had not previously existed."

The fact that a higher percentage of first-generation students than continuing-generation students acknowledged themes of curiosity or discovery as rewarding elements of their CURE course projects suggests more of a positive impact of discovery through CURE research for first-generation students. We interpret this finding to mean that there is increased access to and appreciation of the research experience in CURE courses by first-generation college students compared to continuing-generation students.

Pierszalowski, et al. (2018) describes how CURE courses function as a more available avenue into research for traditionally underrepresented student groups, such as first-generation students. Due to factors such as limited time out of class to participate in research programs, a lack of information or coaching on how to seek out and establish a mentored research experience, and an infrastructural design catered toward more dominant societal groups, first-generation college students experience more barriers to entry into undergraduate research experiences. Due to these barriers, establishing an undergraduate mentored-research experience "may be more daunting for first-generation students, who sometimes encounter more difficulty locating support and resources for navigating university processes" (Pierszalowski et al. 2018, 8).

Martin, et al. (2014) explored the resources, information, and opportunities available to first-generation college students in engineering programs. Specifically, they looked at the limited social capital, or the resources acquired through social networks, that first-generation college students had compared with continuing-generation college students. Through the use of social capital theory, they explain that continuing-generation students "are more likely to have a structural advantage over [first-generation college] students" (Martin et al. 2014, 824) - a "head start" in the network-based resources that may potentiate access to opportunities, such as mentor-based research experiences. "Due to this disparity in key forms of social and cultural capital, continuing-generation students have greater access to undergraduate research experiences than first-generation students." (Pierszalowski et al. 2018, 8). While these statements may hold true for mentored undergraduate research experiences, we attest that first-generation students have increased access to research opportunities, as well as a sense of belonging to the university's research community, when said opportunities are course-based, such as in the CURE program.

Conclusions and Recommendations

It has been established that CUREs have increased the number of first-generation college students who participate in original research at this institution, and this study further finds that first-generation college students report more impactful experiences with curiosity and discovery related to research compared to continuing generation college students. While this study is limited to a cross-section of CUREs from one semester at a single institution, it points to an interesting question as to how CUREs may offer differing impacts on individual students based on their circumstances. As the number of CUREs increase at this institution, the analysis of student reflections will continue in an effort to explore how students of different backgrounds vary in their perceptions and descriptions of their research experiences.

Furthermore, this study illustrates that student reflections need not be extensive to be informative. By creating opportunities for students to describe their experiences within a brief and confidential survey offered at the end of class, students are able to provide candid and personal descriptions of their experience. In this case, the meaningfulness of student reflections is augmented by associating coded responses with demographic data, thereby allowing for the comparison of student experiences between groups. Additionally, the coding approach described here ensures that all student voices are given equivalent weight. Whereas a summary reading of open-ended responses on a survey report makes it difficult to establish patterns and may lead reviewers to focus on the most verbose or zealous responses, the procedure followed in this study establishes patterns in student reflections relative to the course experience and moderates the impact of bias that may occur in reading student verbatim responses.

In terms of implications for assessment professionals, analysis of qualitative data can yield a deeper understanding of student experiences that goes beyond tracking participation rates, analyzing quantitative survey responses, or reviewing the results of direct measures such as student work products. While these measures may provide insight into what happened in class and how students benefited, exploring student reflections on their experiences may reveal why those outcomes came about. Such revelations may enable assessment professionals to offer specific and actionable pedagogical recommendations for refining and improving student learning in undergraduate research courses.

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