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EXPLORING UNDERGRADUATE RESEARCH EXPERIENCES AND PERCEPTIONS OF RESPONSIBLE AND ETHICAL CONDUCT OF RESEARCH (RECR) EDUCATION IN THE BIOLOGICAL SCIENCES AND (BIO)CHEMISTRY DISCIPLINES

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By
Bernice J. Caad
2023

Dedication

This work is dedicated to my children, Byron and Blair.

May your journey through the wonder we call life be filled with endless adventure, and may you overcome every challenge that comes your way. As you explore the world, remember that you are the embodiment of unity and understanding, and let your dual citizenship be a reminder of the bridges you can build and the connections that you can forge. It is my hope that you embrace the values of acceptance, compassion, and respect, and as you venture forth, know that you are loved, supported, and will always have a place to call home.

You have the world at your fingertips.

With infinite love and unwavering belief in your potential,

- Mom.

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by

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THESIS

Presented to the Faculty of the Graduate School of

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Acknowledgments

Coming from a world where a university education seemed as elusive as the Iron Throne, to being in graduate school, feels like a plot twist worthy of Game of Thrones. From Tim Hortons runs to enduring freezing temperatures, who would've thought that this Hobbit-like individual from the land of maple syrup and hockey would one day embark on such an epic journey?

To my husband, Terrance, you are my very own Severus Snape, always by my side and loving me unconditionally. You have been my rock and have shown me that love transcends time and adversity. Thank you for being the "*Always*" in my life.

To my amazing kids, Byron and Blair, you are my little companions who have filled this journey with endless joy and adventure. I hope to one day inspire you to embrace your own quests and never stop exploring knowledge and the world.

To my parents, Reseda and Thomas (William), I'm forever grateful for your sacrifices and for teaching me that with great power (and a good education) comes great responsibility.

To my fantastic family and friends who have been there to lighten the load and provide support through thick and thin, you are my Guardians of the Galaxy. Thank you for reminding me that it's not just about the destination, but also the importance of having awesome company along the way.

To my academic mentor, Dr. Jeffrey Olimpo, you are the Gandalf to my Frodo, guiding me through the treacherous mountains of academia and helping me find my way when I felt lost. Your wisdom and encouragement have been instrumental in shaping my academic growth.

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Abstract

Increasing calls to reform undergraduate (UG) education within science, technology, engineering, and mathematics (STEM) disciplines have emphasized the importance of early exposure to responsible and ethical conduct of research (RECR) education. Historically, RECR has primarily been presented at the post-baccalaureate level, leaving many students without a foundational understanding of what responsible research ethics entails during the course of their undergraduate experience. Over the last decade, course-based undergraduate research experiences (CUREs) have emerged as a promising platform to establish expectations of responsible and ethical conduct through greater accessibility and inclusivity, starting at the freshman level. Interestingly, few studies have examined how undergraduate students and stakeholders have experienced and perceived RECR tenets within authentic research environments such as CUREs. This has left us with an incomplete picture regarding how this education is being presented to and perceived by students, including how instructors view the long-term feasibility of RECR integration within the curriculum. This research seeks to address this by (i) adopting quantitative methodologies to evaluate how undergraduate students in biological science and chemistry disciplines experience and perceive RECR education and (ii) using qualitative approaches to examine how stakeholders view RECR and the factors related to scaling and sustaining this education within CUREs. Collectively, this study will contribute to the creation and integration of RECR activities within CURE curricula with the intent of improving individuals' development of long-term attitudes, habits, and understanding of responsible and ethical research conduct.

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APA	American Psychological Association
CITI	Collaborative Institutional Training Initiative
CURE	Course-Based Undergraduate Research Experience
IACUC	Institutional Animal Care Use Committee
IRB	Institutional Review Board
MARC	Maximizing Access to Research Careers
NIH	National Institutes of Health
NSF	National Science Foundation
PHS	Public Health Service
RECR	Responsible (and Ethical) Conduct of Research
RISE	Research Initiative for Scientific Enhancement
STEM	Science, Technology, Engineering, and Mathematics
UG	Undergraduate
UREs	Undergraduate Research Experiences
UTEP	The University of Texas at El Paso

Chapter 1: Introduction

National Calls to Enhance the Quality of Postsecondary STEM Laboratory Education

Efforts to reform undergraduate (UG) laboratory education within science, technology, engineering, and mathematics (STEM)[5, 16] disciplines have continued to emphasize the importance of student engagement in the process of authentic scientific discovery as a mechanism to enhance academic and professional development[10, 15, 24, 33]. Undergraduate research experiences (UREs) have been viewed as an integral environment to train future generations of scientists[33], as students who participate in UREs have been shown to exhibit significant cognitive, behavioral[9], and affective gains[33] such as increased scientific identity, persistence, enhanced learning through the ability to "think like a scientist"[15, 21], enjoyment and excitement[33], and increased retention[9, 10] and intention to pursue an education or career in STEM[33].

While the benefits of URE participation are many, the current structure of UREs has predominantly been apprenticeship-like, where UGs work closely or one-on-one with an experienced researcher such as a faculty mentor, postdoctoral fellow, or graduate student within an academic laboratory environment[33]. UREs often lack the necessary resources such as time[4], pedagogical materials[21], and finances[10] to involve all or even most matriculated students[15] and, as a result, have historically adopted competitive selection processes and small cohort sizes that are primarily reserved for junior- or senior-level students with previous research experience[15, 16, 24, 33]. This has resulted in inequitable UG laboratory experiences and student outcomes due to inadequate opportunities to engage all students, despite increasing literature which supports the many cognitive, behavioral, and affective gains that can result from UREs[9, 33].

These limitations, coupled with a broader interest in expanding the availability and accessibility of authentic research experiences in UG STEM laboratory education have therefore

prompted the development and implementation of discovery-based research courses, also known as course-based undergraduate research experiences (CUREs)[15, 33]. Through the creation and adoption of national models and institution-wide initiatives[21], CUREs have emerged as an inclusive platform to engage and immerse all course-enrolled students in the scientific research process[24, 33] by addressing a question or problem of interest with a presently unknown outcome through utilizing the same or similar data and tools as professional scientists[15]. CUREs are often the first research experience (and may be the only research experience) for UG students, with primary exposure beginning in introductory, freshman-level courses. They therefore have a greater potential than UREs to influence a student's education and career trajectory due to their ability to provide authentic research experiences at scale and for broader audiences[15, 33].

Studies on the impact of CUREs have further shown that these courses effectively promote the development of many of the same cognitive and non-cognitive outcomes that are also observed in UREs[9, 10, 16, 24]. This could be the result of the autonomous nature of CUREs, as students are given the opportunity to troubleshoot, problem solve, and collaborate much like they would in a real-world research laboratory[9, 33]. CUREs have been shown to promote further gains, as students often have the opportunity to assume more ownership and responsibility during the decision-making process by taking on leadership roles that tend to be less available in traditional UREs, as these roles are usually reserved for faculty mentors or senior laboratory members[15]. CUREs also facilitate organized group work, which allows students the opportunity to enhance their critical thinking skills and explore skepticism on a level playing field, as students who work alongside their peers are less likely to see each other as authority figures, allowing them to voice their opinions freely[15]. CUREs are also beneficial for disadvantaged and underrepresented groups such

as women and minorities, as these individuals tend to have less opportunity to participate in UREs and to interact with or develop relationships with experienced scientists[15, 30, 33].

Findings from Auchincloss et al.[15] also compared CURE and URE student outcomes and found that, while all students gained experimental and theory-based knowledge, only CURE students exhibited gains in their views about science being creative and process-based. Further, CURE students gained a stronger sense of ownership over their projects and higher levels of persistence than their counterparts. Notably, a study at the University of Texas at Austin between 2006 and 2013, which involved a sample of 4,898 UG students, showed that participation in at least one CURE at the introductory level significantly increased a student's likelihood of graduating within six (6) years with a STEM degree, which shows that even one semester has the potential to significantly affect the aforementioned outcomes[33, 53].

As CUREs are accessible through open enrollment and are not contingent based on a student's current academic level or research preparedness, this platform has the potential to expand access to UG research to all students[15, 33]. Through the accessibility and availability of CUREs at earlier stages of a student's academic career, starting at the freshman level, this platform has an increased potential and opportunity to exert a greater influence on students' short- and long-term academic and career trajectories[15, 21, 24]. Therefore, educational reform through widespread implementation of CUREs effectively supports the development of the next generation of scientists and subsequently increases the development of the previously-described cognitive, behavioral, and affective gains[9, 15, 24, 30, 33].

Responsible and Ethical Conduct of Research (RECR)

The ability to conduct research responsibly and ethically is fundamental in advancing the scientific research enterprise and society at large[9, 17]. Absence of this ability could lead to

devastating results such as the corruption of research records, harm to the environment and public health, loss of public support and trust, and threats to national security[30]. Prior to the first calls for responsible (and ethical) conduct of research (RECR) education within the United States, there was a growing awareness of many high-profile cases of demonstrated or suspected scientific misconduct between the late 1970s and 1980s that ranged in scope and severity from fabrication, falsification, and plagiarism[23, 30] to public outcries in response to interventions such as the Tuskegee Syphilis Study[5, 14, 23]. The public viewed these instances as a betrayal, resulting in the degradation of public trust, the production of negative connotations of research, and a lack of support surrounding the integrity of science as a rigorous discipline[14, 23]. This led the United States government and its agencies to explore the implementation of procedures aimed at promoting scientific integrity in federally-funded research through the implementation and requirement of RECR education[18, 30].

Over the past thirty years, RECR programs have continued to increase in prevalence[23] due to requirements[21, 30] set by federal agencies[10], such as the NIH[3, 12, 14, 23], the Public Health Service (PHS)[2, 7], and the National Science Foundation (NSF)[4]. Despite the longevity of these training requirements, however, explicit guidance on how to achieve the aforementioned intended outcomes is not well defined[2, 23]. This has led RECR education to remain highly variable in terms of content, format, goals, and effectiveness[8, 23] and could further be a result of varying guidance from federal departments and agencies. For example, the NIH provides an outline of RECR topics that can be explored: 1) conflict of interest; 2) human subjects, live vertebrate animals, and safe laboratory practices; 3) mentor/mentee responsibilities and relationships; 4) collaborative research, including with industry; 5) peer review; 6) data acquisition and laboratory tools, management, sharing, and ownership; 7) research misconduct; 8) responsible authorship and publication; and 9)

the scientist as a responsible member of society, contemporary ethical issues in biomedical research, and the environmental and societal impacts of scientific research[14, 23]. The PHS also provides long-term goals for RECR instruction such as: 1) increased knowledge and sensitivity to responsible research conduct; 2) improved ability to make ethical and legal choices related to research conflicts; and 3) a developed appreciation for the range of accepted research practices[7]. In contrast, the NSF does not provide an outline of instructional topics and instead provides institutional autonomy, which allows the applicable institution to implement RECR education as they deem appropriate[4, 8, 12].

RECR is considered the primary strategy to educate scientists about ethical concerns, regulatory requirements[17], responsible research practices[10], and to build awareness about the application of established professional norms and ethical principles associated with scientific research[14]. However, lack of guidance has subsequently resulted in the creation of a staggering number of RECR programs, such as the widely utilized Collaborative Institutional Training Initiative (CITI)[44], as well as an abundance of other resources such as curricula, textbooks, and online materials[8, 36]. These resources have subsequently resulted in a wide range of outcomes such as knowledge, attitudes, and perceptions[14] and mixed opinions about whether current pedagogical methods to convey RECR education are effective[8]. Within UG education, exposure to RECR tenets **(Table 1)** continues to be neglected or intermittent[15], with initial exposure primarily beginning at the post-baccalaureate level[1, 10, 21]. This has resulted in many UG students continuing to receive little to no targeted RECR education prior to graduation[1, 10, 14, 15] even though topics such as research misconduct, data management, and regulatory standards are routinely faced within UG laboratory environments and the real world[1, 5].

Table 1. RECR tenets as defined by Mabrouk[4].

Concept	Definition
Personal Misrepresentation	*A form of misconduct in which an individual provides a false or misleading oral or written declaration of their educational background, technical skills or expertise, or achievements*
Falsification	*The practice of omitting or altering research materials, equipment, data, or processes so that the results of the research are no longer accurately reflected in the research record*
Fabrication	*The practice of inventing data or results and recording and/or reporting them in the research record*
Plagiarism	*The practice of using another person's original ideas, processes, results, or words without giving appropriate credit to the other person*
Intellectual Property	*Nonobvious ideas, creative inventions, or processes such as trademarks, copyrightable works, or patented inventions*
Authorship	*The practice of identifying those individuals responsible for the integrity and quality of ideas, experimental work, interpretation, and written expression of a significant work being published*
Confidentiality	*An agreement based on mutual trust that protects intellectual property and limits to whom and what information may be disclosed*
Conflict of Interest	*A situation in which an individual who is acting to represent the interests of another has personal, fiduciary, or professional interests that have the potential to impede their ability to act impartially on behalf of the other person*

Historically, RECR education has been omitted from primary, secondary[23], and postsecondary education due to the assumption that one's moral code was a culmination of learned behaviors fostered by their environment (e.g., their family, instructors[10], and mentors[5, 14, 23]). Although one's environment is likely a key component in the establishment of one's moral code, learning responsible conduct within these contexts is often highly variable[10] and does not always translate into academic or scientific integrity[5]. Differences in culture, religion, and socioeconomic status can also significantly impact how RECR tenets are interpreted, such as original or cited works in the context of plagiarism, which can vary significantly based on where one receives their secondary or postsecondary education[14]. In the rare event that RECR education is taught at the UG level, it is typically presented as a separate, unconnected lecture or seminar with pedagogical

techniques, such as role-playing and case studies[5], and has resulted in concerns over this disconnect leading to the impression that science and ethics are separate instead of heavily intertwined[1]. This disconnect was further observed by Del Carlo and Bodner[26] who found that: 1) students believe that the classroom laboratory is not comparable to a research laboratory, and 2) these views about the differences between laboratory settings impacted how students perceived and applied RECR tenets. This further supports the need to deliver effective, engaging, and meaningful RECR education starting from the very beginning of one's educational and professional career, especially as the scientific enterprise continues to grow[1, 5, 10].

The efficacy of outcomes associated with UG RECR education remains largely unknown; however, several studies suggest that while this education may increase knowledge, this does not always translate into ethical decision-making or improved attitudes[4]. Integrated RECR education should focus not only on building knowledge but also on increasing awareness about the potential ethical dilemmas that may be encountered so that students can develop the skills necessary to overcome these challenges[23], to include complex and unforeseen grey dilemmas that cannot be solved with a simple yes/no answer and that often have many viable solutions[37]. Therefore, it is necessary to restructure how RECR education is currently introduced and integrated within existing laboratory curriculum[13] to align with current calls to reform UG education and to emphasize the importance of accurate, unbiased data in research within both academic and professional settings[2, 5, 10].

Exemplars of RECR Education in Undergraduate (UG) STEM Curricula

Many teaching methods and approaches have been explored to integrate research ethics within STEM curricula[21], with the most utilized approaches typically including a combination of passive or active activities such as lectures, case studies, and roleplay[5]. Current research about

RECR pedagogy, however, has yet to demonstrate a single training exercise or educational program that can enhance the three key learning outcomes of knowledge, moral reasoning, and attitudes at the same time[34, 36]. Some examples of the approaches that have been used to deliver RECR education are as follows: Keiler et al.[1] created an ethics course to encourage the development of analytical decision-making. In this course, students were able to practice and improve their existing skills by exploring case studies about current topics, such as those highlighted in the media and public health, with the aim of promoting relatability to the student's individualized research projects and to promote awareness of broader societal impacts. Nebeker[8] introduced practical tips for educators to connect evidence-based principles to research-informed practices within the context of RECR. These tips included emphasizing the need for intentional and explicit course objectives, incorporating practice and feedback through discussion to build student confidence, and prioritizing RECR topics (relevant to the course) to increase awareness.

Sweeting[5] developed a professional ethics course that consisted of assigned readings, videos, case studies, and guest speakers to encourage students to identify and navigate ethical issues and potential solutions. In this course, the instructor acted as a guide to foster discussion about ethical values and accountability in decision-making through evaluating cases that involved unethical behaviors in popular media and responsible conduct within a professional environment. Overall, the goal was to encourage students to recognize and solve ethical issues for themselves to internalize learning[5]. Similarly, Mabrouk et al.[4] facilitated workshops over a three-year period with six different URE programs, which resulted in significant gains in participants' comprehension of many key RECR terms (e.g., fabrication, falsification, plagiarism, intellectual property, and confidentiality). However, student definitions of terms such as personal misrepresentation, authorship, and conflict of interest remained largely deficient, and students' ability to apply these

concepts to their own research projects were not significant. Rosnow[6] implemented role-playing to discuss RECR dilemmas by playing "devil's advocate." In two courses, a lecture was given based on ethical principles outlined by the American Psychological Association (APA); however, only one of the courses experienced an additional role-play activity. Prior to role-playing, the class provided a benefit rating and were asked to imagine themselves as primary authors or researchers, while the rest of the class acted as a peer review board to evaluate the scientific value of their "unethical study." Afterward, students provided an updated benefit rating, and the results showed that the role-playing exercise had a significant effect on the final benefit ratings[6].

Zaikowki et al.[18] explored a multi-tiered approach designed to enhance ethics education through the introduction of RECR principles starting in the introductory UG curriculum for all majors. The first tier involved introducing RECR principles through a seminar-based approach, where the topics ranged from high-profile to high-interest issues. The second and third tiers involved the integration of ethics in major courses through essays and case studies about specific ethical issues that were course relevant to enhance the understanding of scientific, social, and moral issues from an ethical perspective. The third and fourth tiers involved specialized senior seminars, capstone courses, and research experiences to further develop the understanding and knowledge of ethical issues that were fostered in the previous tiers[18]. Lastly, Grasse et al.[34] introduced a choice-based interactive narrative game titled *Academical* with the goal of improving conceptual knowledge (e.g., sensitivity to societal expectations), moral reasoning (e.g., judgment), and attitudes about RECR by asking players to address routine ethical dilemmas through exploration and decision-making.

These varying approaches align with current trends in RECR education[2, 4, 8] such that each of these activities differed in content and goals[8]. While these serve as a helpful starting point in

navigating how to incorporate RECR within traditional "cookbook" laboratory and research environments, including resources such as a "how-to" guide published by the Council of Undergraduate Research[52], RECR experts further emphasize that the best pedagogical methods should be engaging, meaningful, and teach not only cognitive skills but also foster positive attitudes, as building knowledge is only successful if motivation is also present[34]. Despite this, studies that specifically explore methods on how to approach and successfully integrate RECR education within the context of CUREs remains few[21].

CUREs as a Model for Early Exposure to RECR

Building on concerns about the effectiveness of RECR training, national reports have continued to heavily emphasize the importance of exposing UGs to RECR values such as accountability[10, 21] and integrity, which also extends to the core principles of honesty, fairness, objectivity, openness, trustworthiness, and respect for others from the very beginning of the research process[14, 17, 21-23, 49]. Heitman et al.[3] assessed incoming graduate students for their baseline knowledge of RECR tenets, which revealed low scores, as many respondents did not appear to know basic RECR concepts or standards even though many had reported previous research or mentoring experiences. These findings suggest that participation in UREs or previous RECR programs does not necessarily translate into knowledge. Further, participation in a handful of training courses or programs is likely insufficient in relaying meaningful RECR education[3]. Thus, integration of RECR education at the UG level has the potential to teach a professional code of conduct[13, 14], foster an increased awareness of how to navigate and overcome potential ethical challenges[23], and promote mindfulness about how actions can impact society and the UGs themselves starting from the very beginning and continuing throughout their academic and professional careers[13, 14]. Early exposure could further minimize the potential for long-lasting and

detrimental effects such as decreased trust[19, 30] and noncompliance, both of which can result in the suspension of protocols, loss of research funding privileges, and publishing restrictions[20].

As alluded to previously, CUREs are discovery-driven courses that have emerged as an inclusive platform to introduce all students to authentic research experiences[24] and are an effective alternative to traditional "cookbook" laboratories and current URE accessibility issues[16, 21, 24, 33.] Integrating RECR education within CUREs has the potential to significantly impact the development of a student's ethical awareness by ensuring that they have the opportunity to learn how research is conducted responsibly and with integrity by observing how RECR tenets fit within the day-to-day research process, such as through learning to accurately maintain research records and notebooks from the very beginning[9, 10, 14, 15]. CUREs have several hallmarks **(Figure 1)** that further support their potential as an ideal platform to facilitate RECR education through the exploration of evidence-based reasoning, contribution, communication, and expansion of existing knowledge[10, 15, 33].

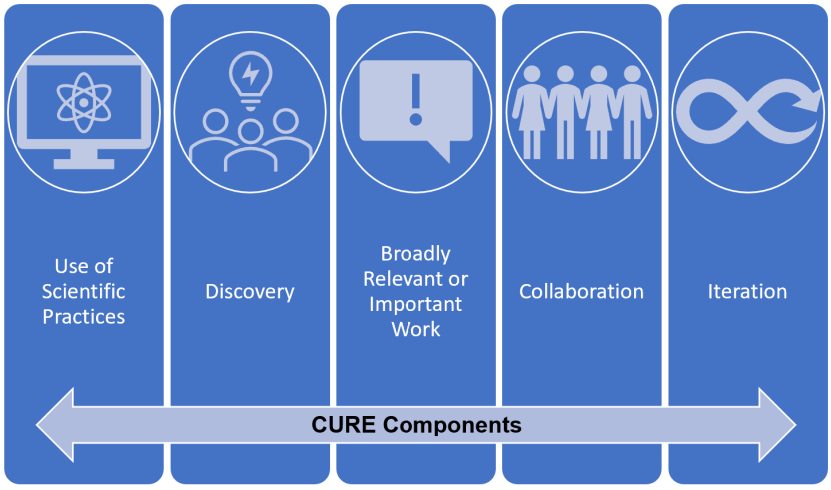


Figure 1. Course-based undergraduate research experience (CURE) hallmarks.
Adapted from Donegan et al.[41] CUREs promote the **use of scientific practices** (e.g., techniques, skills, tools) to facilitate **discovery** – the exploration of novel questions. This is done in a **collaborative** and **iterative** manner, with the intent that research findings will be **broadly relevant**. In other words, the work that students do within the CURE should have importance to one or more communities beyond the course[15].

Expanding on these hallmarks, CUREs are an ideal platform to integrate RECR education within the UG curricula because it allows for: 1) meaningful RECR education to be directly infused into the course instead of being taught separately; 2) the reinforcement of RECR principles through immediate application of concepts that are currently being explored; 3) the opportunity to reflect on the fundamental role of RECR within an authentic research environment; and 4) an increased number of students to receive formal and purposeful RECR education as part of their routine academic experience[10, 14].

Within CUREs lies the opportunity to implement RECR education in a standardized manner and the potential to substantially impact all enrolled students' awareness of ethical considerations and responsible research habits as they relate to scientific endeavors[10]. The need to fully integrate RECR education within the CUREs curricula should be prioritized, as its current absence could shift student perceptions toward thinking that RECR habits are unrelated to real-world research experiences[9]. Therefore, it is evident that CUREs can serve as a promising environment to facilitate early exposure to RECR through their highly accessible, introductory level platform[10, 15, 33], therefore allowing for increased opportunities to foster students' development and attitudes toward research ethics by conveying the importance of core RECR principles and values[5, 10, 21].

Sustainability and Scalability of RECR within CURE Curricula

Scientists teaching other scientists is well-documented as a scale-up technique; however, this strategy has revealed modern challenges, as the ability of a senior scientist to effectively teach RECR is often limited by increasing demands and responsibilities such as maintaining research funding and completing administrative tasks, to also include limitations to their own knowledge due to lack of formal mentoring and training[23]. Within CUREs, integrating RECR education has

revealed similar challenges with respect to scalability and sustainability, such that scale-up largely relies on educators and their ability to receive adequate support and guidance within their institutions[9, 27]. Pedagogical techniques to convey RECR standards and practices across CURE curricula on a widespread scale are currently limited[10], highly variable[21], or unclear[38]. However, many instructors have reported that they continue to omit RECR instruction from the curriculum due to a lack of pedagogical experience, lack of institutional or departmental requirement (to include low faculty support)[9, 10, 21], lack of resources such as shared pedagogical materials, or lack of time and finances to develop the appropriate materials[10, 21]. Scaling-up is generally described as an intentionally guided process that emphasizes institutionalization and sustainability into an existing system rather than expanding current coverage[38]. Institutions play a vital role in this process, as they are generally responsible for not only supporting the initiation and sustainability of educational interventions, but also for establishing expectations, to include articulating learning standards for students, faculty, and staff to ensure the intervention's success[46].

Similar to public health interventions, the design of educational interventions is generally encouraged to have a scalability plan developed in the early stages to increase impact and achieve the desired educational goals[38]. In this context, scalability is defined as the "ability of an intervention to be effective on a small scale or under controlled conditions which can also be expanded under real-world conditions to reach a greater audience, all while retaining its effectiveness"[54, 57]. In planning sustainable, large-scale educational interventions, Elmore[55] recommends five design principles: 1) that a tight instructional focus be maintained; 2) that accountability for practice and performance be part of the routine; 3) that the practice of observation and analysis be transparent; 4) that schools be allowed increased flexibility based on their performance and capabilities; and 5) that schools be allowed increased flexibility based on

the quality of their results. Zamboni et al.[38] also evaluated existing frameworks and discovered five common themes for consideration when planning strategic scale-up of interventions, to include: 1) attributes of the innovation or intervention; 2) attributes of the community who were introducing or supporting the scale-up; 3) attributes of the community receiving the innovation or intervention; 4) the sociopolitical climate; and 5) the scale-up strategy.

Currently, the integration of RECR education within CUREs requires substantial coordination among all parties involved in their organization, design, and implementation. Therefore, its integration is typically achieved by following an adapted scaffold approach that involves: 1) the identification of relevant RECR topics and learning objectives; 2) the design and identification of relevant mini-lessons; 3) the development and identification of assessments based on the curriculum; and 4) the professional development of CURE facilitators[10]. Interestingly, this scaffolding approach and previously-described limitations contribute to current challenges associated with the scaling and sustainability of RECR education, as these processes are largely isolated[21], collectively highlighting a need to create shared resources and a standardized curriculum that can be applied across all CURE courses, with minor changes based on relevance[21]. If a CURE involves human subjects or vertebrates, as an example, then the course could focus on regulatory committees such as the Institutional Review Board (IRB) and Institutional Animal Care and Use Committee (IACUC) that oversee human subjects and animal research, respectively. Alternatively, if a CURE involved large-scale datasets, then the course could focus on data management and falsification of data[10].

Overall, there is an abundance of models and frameworks that provide guidance on how to apply scalability efforts for both applied and full educational interventions[56]. However, guidance on how to scale up and sustain RECR education within a CURE environment remains non-

existent[21]. This could be due to the general concept of scalability and sustainability to enhance performance within a local system still being relatively new[38] and, within CUREs, still a foreign concept[21]. Regardless, it is integral that the scale up approach promotes active learning, engagement, and discussion, as active learning provides the opportunity to not only model but also practice how ethical dilemmas can be navigated[36]. Therefore, although various methods to sustain and scale educational interventions exist within the literature, it is necessary to explore existing scale-up frameworks and principles to evaluate their applicability so that RECR education can be effectively sustained and scaled across CURE curricula.

Chapter 2: Exploring Undergraduate Researchers' Experiences and Perceptions of Responsible and Ethical Conduct of Research (RECR) Education in Biological Sciences and (Bio)Chemistry

Introduction

Responsible and ethical conduct of research (RECR) is often defined as "good citizenship applied to professional life," in which scientists adhere to best practices[23] by reporting their findings honestly, accurately, and objectively[22]. Over the past few decades, RECR education has continued to increase in prevalence[10]. However, its autonomous application has continued to exhibit high variability[20, 21], and challenges have emerged in evaluating its efficacy[2, 8]. Until RECR education is standardized across curricula, it is likely that this variability will continue, as evidenced by a recent assessment of biomedical programs, which reported that only 17% of institutions required formal RECR education[10]. Heitman et al.[3] also evaluated the current landscape of RECR by recruiting incoming biomedical graduate students and assessing their knowledge of RECR topics. The scores were described as unexpected and universally low, with an average of 59.5% correct responses, suggesting that previous research or mentoring experiences are often not enough and that individuals should not be able to opt out of refresher courses simply due to prior training or education. Findings from Heitman et al. further highlight the importance of introducing RECR concepts throughout a scientist's career, starting at the beginning of one's undergraduate degree, as instruction, research experience, and mentoring at this stage is fundamental in developing lifelong positive attitudes about research and scientific integrity[3].

The current study was intended to build on the work of Diaz-Martinez et al.[21] and aimed to evaluate the current landscape of RECR education at The University of Texas at El Paso (UTEP) by examining the differences in experiences and perceptions of RECR among undergraduate

students who participated in biology and (bio)chemistry CUREs, the intent being to establish a baseline upon which to tailor the creation, implementation, and evaluation of CURE-specific RECR educational materials. It was hypothesized that undergraduates who participated in the CUREs would report encountering several RECR core concepts (e.g., authorship, data fabrication, collaboration) during their time in the course, although the level of exposure to these (and other) topics would likely vary between students. Specifically, this research was guided by the following central focus:

> *What experiences do undergraduates report with respect to RECR education in the context of biological sciences and (bio)chemistry CUREs at a Hispanic-Serving Institution in the American Southwest?*

A quantitative, survey-based approach was employed to address the above question, with all students in biological sciences and (bio)chemistry CUREs at UTEP eligible to participate in the study (see *Methods* below for further details). Through findings obtained from this study, and the subsequent genesis of new and relevant RECR resources, I hope to encourage the development of improved attitudes and understanding toward RECR topics.

Methods

Participant Recruitment: Participants (N = 71; 80% of all eligible individuals) represented a convenience sample consisting of undergraduate students enrolled in biological sciences and (bio)chemistry CUREs at UTEP in Spring 2023. Students were verbally recruited within their courses after permission was obtained from the instructors of record. This project was

approved by The University of Texas at El Paso's Institutional Review Board (IRB) under protocol ID# 1878331.

RECR Survey: An instrument entitled "Perceptions and Experiences of Responsible and Ethical Conduct of Research (RECR) Survey" **(Appendix A)** was deployed in-person once at the end of the semester to capture student responses. Survey items were adapted from Diaz-Martinez et al.[21] and Mabrouk[4], who previously evaluated faculty and students about their perceptions and knowledge in the context of RECR. The adapted survey consisted of closed- and open-ended questions covering the following categories: 1) general demographic questions; 2) experiences related to exposure of RECR education and issues; 3) perceptions regarding the importance of RECR concepts; and 4) RECR type and frequency (e.g., the right time to introduce RECR). Open-ended survey responses were reproduced verbatim for reporting purposes[42], whereas closed-ended responses were entered into SPSS (v.27; IBM) for the purposes of frequency analysis[41].

Results

Respondent Demographics and Characteristics: Respondents (N = 71) predominantly self-identified as Latino/Hispanic (85.4%) and female (73.2%, **Table 2**). They represented two categories of self-identified laboratory experiences, including CURES only (69.0%) and CURES with previous or current faculty mentorship (31.0%). Students' prior level of RECR training varied, to include moderate (49.3%), extensive (18.3%), high (14.1%), or no training (16.9%), with one respondent (1.4%) being unsure.

Table 2. Demographics and characteristics of respondents.

Laboratory experiences	**No. of respondents (%)**
CURES only	49 (69.0)
CUREs with faculty mentorship	22 (31.0)
Level of RECR training	**No. of respondents (%)**
Extensive (a full semester course)	13 (18.3)
High (multiple workshops and/or seminars)	10 (14.1)
Moderate (a required workshop or seminar)	35 (49.3)
None	12 (16.9)
Other: Unsure	1 (1.4)
Academic classification	**No. of respondents (%)**
Freshman	39 (54.9)
Sophomore	21 (29.6)
Junior	8 (11.3)
Senior	3 (4.2)
Academic discipline	**No. of respondents (%)**
Biochemistry (CHEM)	11 (15.5)
Biological Sciences	32 (45.1)
Cell and Molecular Biochemistry (CBCH)	8 (11.3)
Microbiology	1 (1.4)
Neuroscience	5 (7.0)
Other: Clinical Laboratory Science, Forensics, Geophysics, Physics, Psychology	12 (16.9)
Race and/or ethnicity	**No. of respondents (%)**
American Indian or Alaska Native	3 (4.2)
Asian	6 (8.4)
Native Hawaiian or Other Pacific Islander	1 (1.4)
Latino/Hispanic	60 (84.5)
Caucasian (White)	7 (9.9)
Multi-racial/Multi-ethnic	1 (1.4)
Prefer not to indicate	1 (1.4)
Gender identity	**No. of respondents (%)**
Female	52 (73.2)
Male	17 (23.9)
Non-binary	2 (2.8)

Respondents also reported various levels of academic classifications and majors, with the classification of freshman (54.9%) and academic discipline of biological sciences (45.1%) predominantly reported.

CURE Students' Experiences with Respect to RECR Education: Respondents were first asked to indicate the extent to which they received formal (i.e., structured) RECR education within the context of their CUREs. The majority of students (71.8%) noted that such education was included often, most of the time, or all of the time in the course. To complement these data,

participants were also prompted to indicate the types of RECR education that they have received outside of in-class or program-required trainings. This inquiry revealed that the majority of individuals (73.2%) reported acquiring no additional education or training. The remaining participants indicated that they had engaged in other institutionally-sponsored seminars or workshops (19.7%), online training (5.6%), or externally-offered experiences (7.0%).

To further investigate the manner by which RECR education was experienced by CURE students, respondents were asked to indicate the setting(s) in which they have experienced RECR training, as this may provide a better idea about the current state of its delivery **(Figure 2)**.

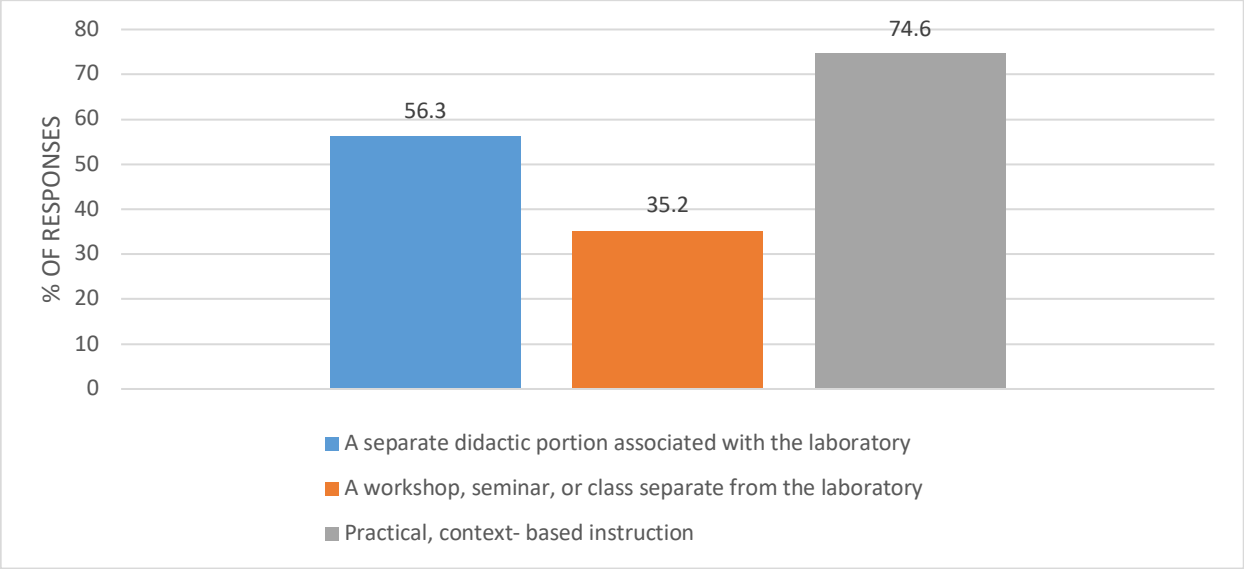


Figure 2. The frequency that respondents experienced the integration of RECR education within their CUREs. Note that the sum of all percentage values exceeds 100%, as participants could select more than one response option.

Respondents predominantly indicated that RECR education was experienced within the laboratory environment through practical, context-based instruction (74.6%). Based on the highly-interactional and iterative nature of CUREs[15], it is promising that RECR education is largely being experienced within the CURE ecosystem itself or via a separate didactic

component that is associated with the laboratory (56.3%), instead of in a separate, unreleated workshop, seminar, or class (35.2%). However, further integration should be pursued, as separation between authentic laboratory enviornments and coursework could result in students experiencing a disconnect between these environments and could therefore subsequently impact how their perceive and apply RECR tenets long-term[1, 26].

To next document the types of RECR issues that were experienced by individuals in our sample, respondents were asked to indicate which RECR-related issues they encountered or had to resolve in the CURE, as this may impact how future RECR curricula is structured and delivered at UTEP. Respondents indicated that the three most frequently-experienced issues were related to general laboratory safety (59.1%), collaboration (59.1%), and mentor/student responsibilities (52.1%; **Figure 3**). Conversely, the issues that were experienced or encountered the least included research misconduct (19.7%), reporting and publications (22.5%), data management (33.8%), and authorship (33.8%).

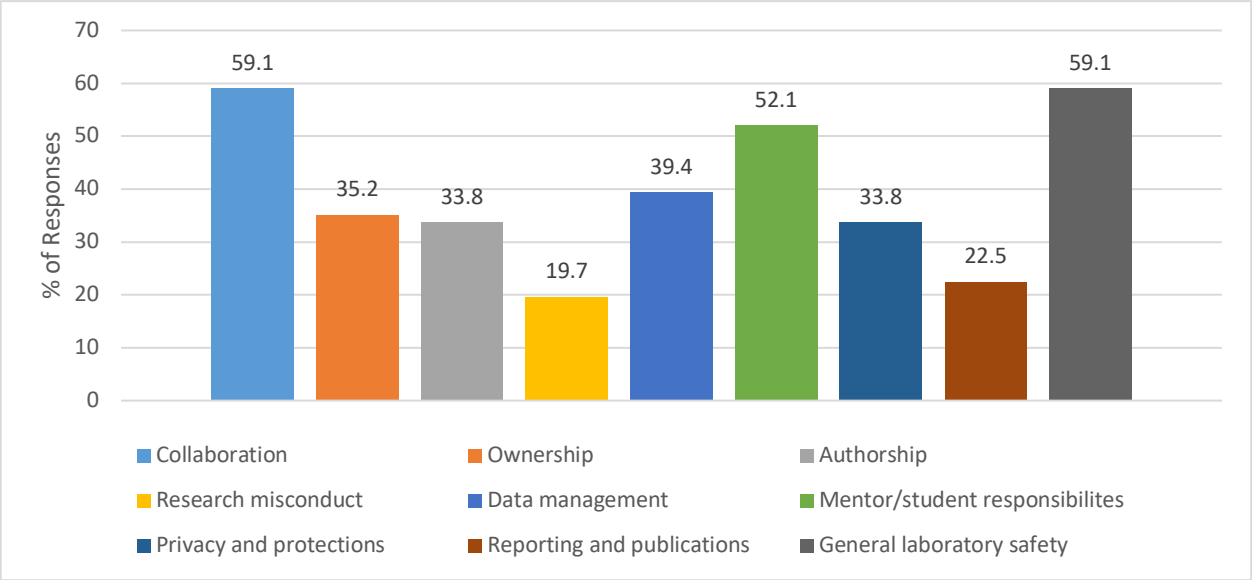


Figure 3. RECR issues that respondents encountered or had to resolve in their CUREs. Note that the sum of all percentage values exceeds 100%, as respondents had the option to select more than one topic.

Because respondents were largely undergraduate students at the freshman level, these data are not surprising, as general laboratory safety is a standard educational component delivered within many STEM disciplines, and mentor/student responsibilities, including expectations, are often reported as challenging for incoming freshman to navigate[14, 36, 63]. Issues related to collaboration are also expected, as authentic research experiences are highly interactional in nature[15, 24]. The RECR issues that were experienced and encountered the least were unexpected, as issues related to research misconduct (e.g., fabrication and falsification) have previously been reported by Mabrouk[4] as the most frequently experienced dilemmas.

Respondents were subsequently asked to identify the types of pedagogical techniques utilized by their instructors to deliver formal RECR education within the context of the CUREs **(Figure 4)**.

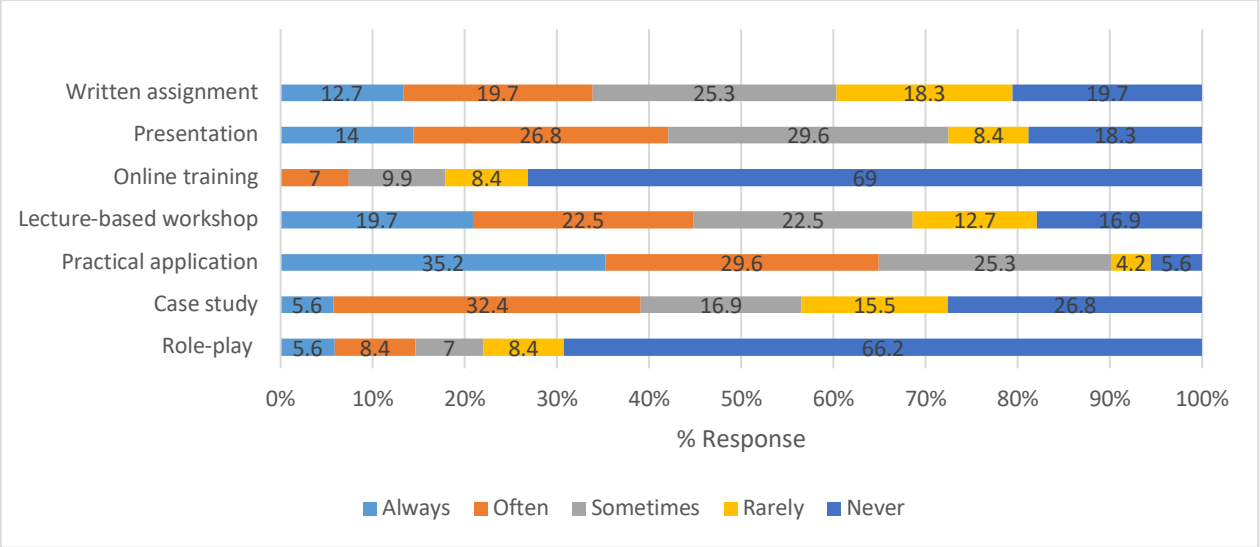
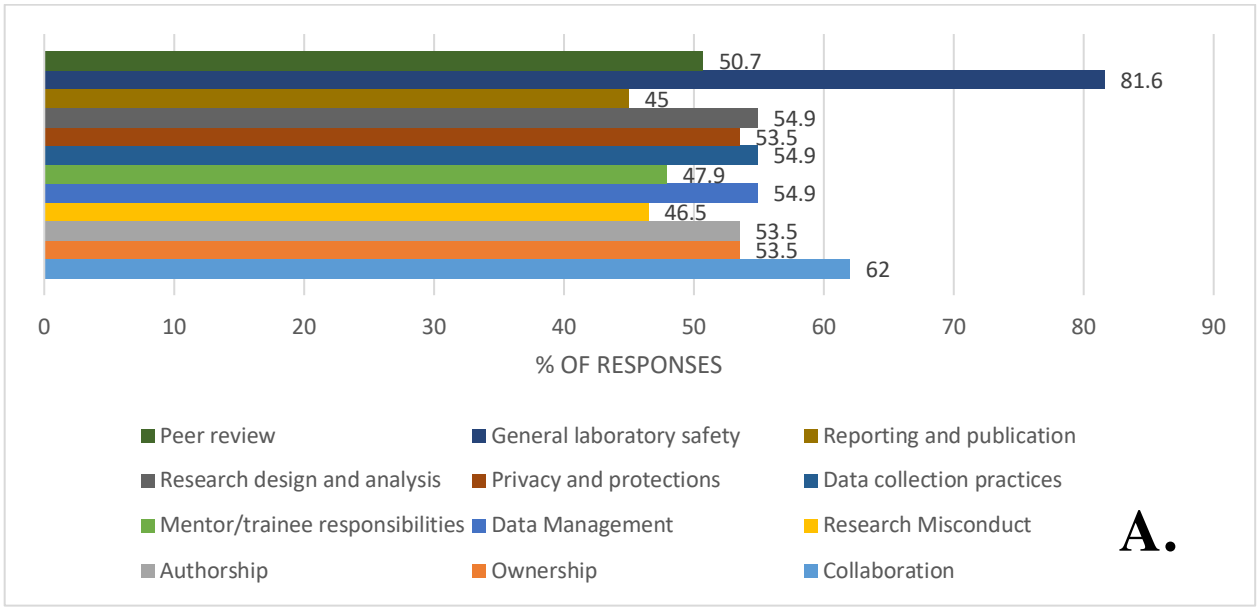


Figure 4. The extent to which specific pedagogical techniques were experienced in a respondent's CURE to deliver RECR education.

As displayed in the above figure, the pedagogical techniques that were experienced most frequently (i.e., sometimes, often, or always) to deliver RECR instruction within CUREs were practical application (90.1%), presentations (70.4%), or lecture-based workshops (64.7%). In contrast, online training (77.4%) and roleplay (74.6%) were experienced rarely or never. This is not surprising, as CUREs often incorporate both a lecture component and an iterative approach to explore a problem or question of interest[15] and do not often include an online training component, as this is largely reserved for faculty-mentored laboratories with federal funding[30]. It was also not surprising that roleplay was experienced infrequently, as the implementation of this activity typically involves an abundance of resources and time to effectively design[61, 62], both of which are often cited as barriers related to RECR integration within STEM[10, 21].

Respondents were then asked to report on the specific RECR topics that they had received education on in their CUREs **(Figure 5.A)** and the frequency that they were assessed for their understanding and skills related to these topics **(Figure 5.B)**.



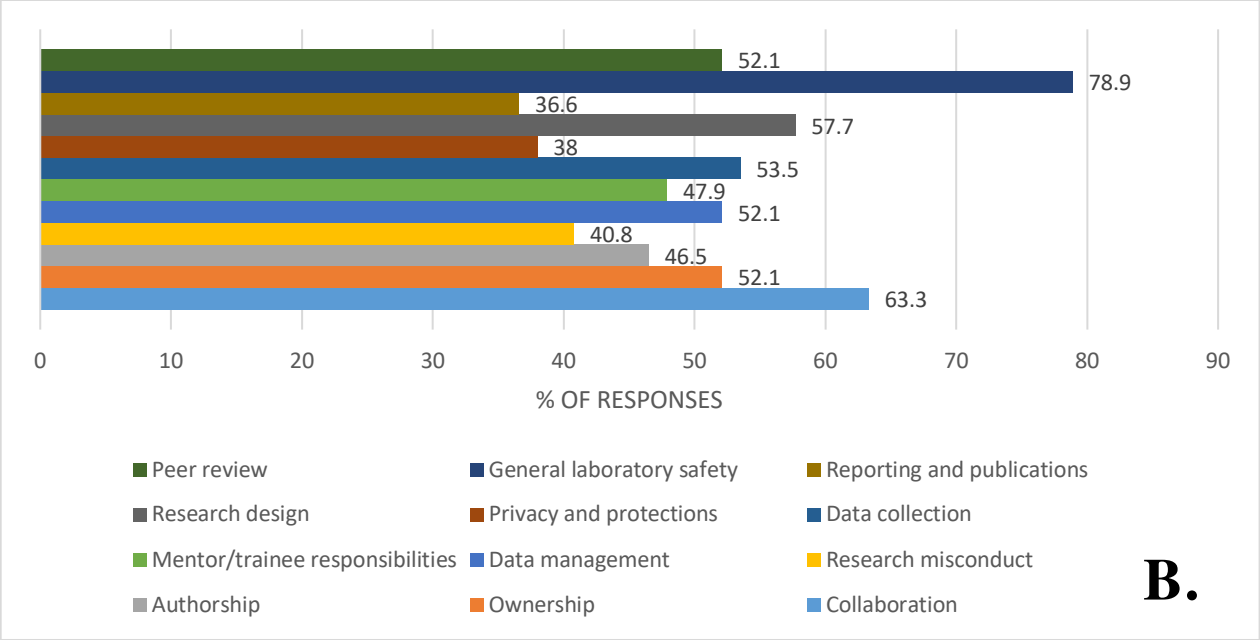


Figure 5. The RECR education experiences of CURE students. (A) The frequency of which specific RECR topics were addressed across CUREs. (B) The frequency that respondents were assessed for competency, such as their understanding and skills, about specific RECR topics.

Interestingly, respondents reported that education about general laboratory safety (81.6%) and collaboration (62.0%) were the specific RECR topics most frequently experienced and assessed (78.9% and 63.3%, respectively). Respondents further noted that specific training about the topic of reporting and publications was least frequently experienced (45.0%) and assessed (36.6%). The reported frequency of specific training related to general laboratory safety is unsurprising, because many undergraduate students are new to the research environment, and, therefore, it is necessary to emphasize the importance of safe laboratory practices rather than other aspects of RECR[21]. It is also likely that specific training about reporting and publications was less frequently experienced, as authorship, while possible, is not frequently experienced by undergraduates within CUREs[31].

The Perceived Best Time to Introduce RECR in CUREs: At the end of the survey, participants were asked about their thoughts related to the timing of RECR education, to include what they perceived to be the best time for its introduction within CUREs **(Figure 6)** and the reasoning for their determination **(Table 3)**. Interestingly, respondents largely indicated that the beginning of the course (85.9%) was the best time to introduce RECR education and that the end of the course (36.6%) was the least ideal time. "Lack of initial knowledge" was cited as a reoccuring theme for why RECR education should be introduced early on in CUREs **(Table 3)**.

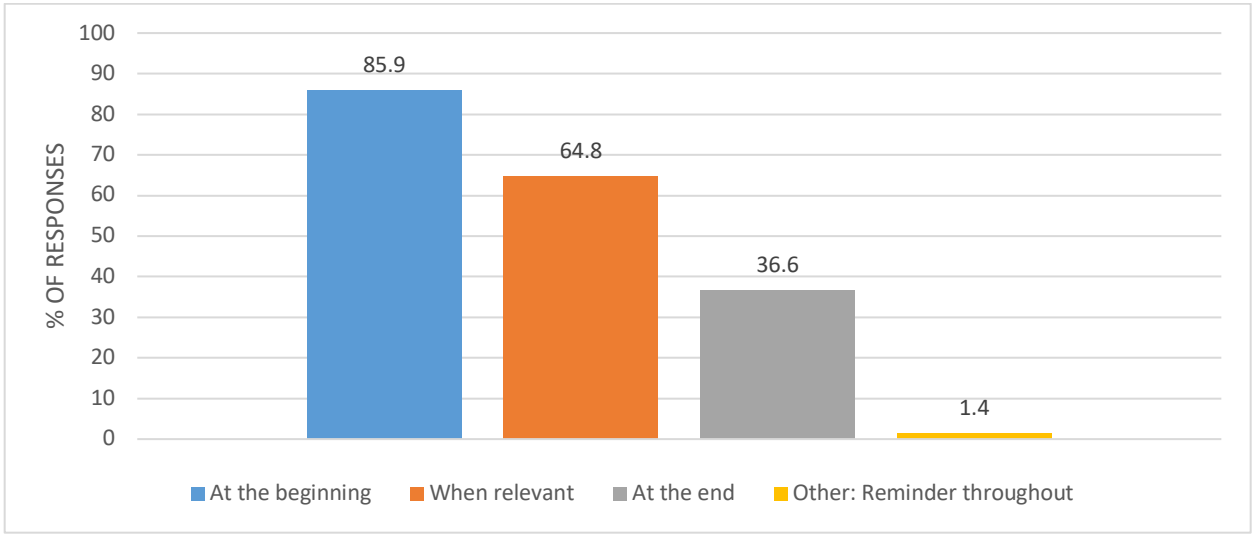


Figure 6. Respondents were surveyed about the perceived best time to introduce RECR education. Note that the sum of all percentage values exceeds 100%, as participants could select more than one response option.

Table 3. Participant rationales regarding the timing of RECR education in CUREs.

Sample open-ended survey responses:
• "Because it is better to leave this clear from the beginning, the labs are usually done with dangerous material and chemicals. It is also important to manage data responsibility, or it can cause bias in the research. • "Because why would you endorse a gap in the responsibility of ethics." • "I believe that most students may not know some of the ethical and professional guidelines of the laboratory and to avoid conflict and misunderstandings, it is best for a student to learn about these topics before entering the field. It is also important to keep it fresh in a student's mind when it is relevant. • "I think it is important for RECR topics to be introduced at the beginning of the experience, as it allows the student to prepare and know how to conduct themselves properly both when working in the lab and when writing up reports." • "RECR topics are the foundation of responsible and moral science. When taught early, these topics become intrinsic to young researchers."

Discussion and Limitations

Respondents reported that they had frequently encountered or had to resolve RECR-related issues as part of their routine academic experience, particularly in the context of CUREs, suggesting that research-driven laboratory curricula may serve as viable models for early exposure of undergraduates to RECR principles[10, 14]. Although participants self-reported that RECR education is currently being provided to them in the CUREs environment, the explicit nature of this education remains unclear, such as whether this training is intentional or through a reactive approach[20]. The delivery of RECR education was largely reported to be experienced through practical application, presentations, or lecture-based workshops, with active learning techniques such as roleplay being adopted less frequently. Studies examining the pedagogical efficacy of RECR education strongly encourage the use of active, engaging learning activities to promote thoughtful reflection and discussion[34]. Findings from Rowe et al.[64] further support the use of active learning techniques, such as gamification, as engaged students have been shown to experience

greater learning gains and increased problem-solving performance, regardless of prior subject knowledge.

It is of little surprise that respondents most frequently encountered or had to resolve issues related to general laboratory safety, collaboration, and mentor/student responsibilities, as freshman-level students, being new to higher education, are often faced with challenges related to navigating their new environments, to include conducting coursework and research, working with their peers, and understanding expectations[21]. While these issues were most frequently reported, and training and assessment about these specific topics were also frequently experienced, the content of this training remains unclear and further supports the need for a shared, centralized hub of RECR resources[21].

Respondents reported few experiences related to extracurricular RECR education, with only 19.7% reporting that they had participated in institutionally-sponsored training such as a seminar, workshop, or other training modules beyond their CURE. It is unclear whether this is due to lack of interest, lack of requirement, or lack of availability or awareness. When asked about the best time to introduce RECR education, respondents overwhelmingly indicated that the best time would be at the beginning of the CURE, the rationale being that students should be informed about the nuances of RECR from the outset so that they can be mindful and aware of the influence of RECR factors. However, a clear path related to the integration of RECR education within CUREs, to include timing, requires further exploration.

I wish to acknowledge several potential limitations of my research. First, while survey response rates were satisfactory, I was unable to capture data from one biological sciences CURE where the instructor of record declined to participate in the study. Therefore, it remains unclear how student data from that CURE section may have impacted the results presented herein.

Relatedly, the survey was distributed to CURE students toward the end of the semester and close to final exams, which may not have been ideal for maximal participation regardless due to increased cognitive load and stress during that time. Strategies to overcome these challenges in the future include increasing the number of rounds of survey distribution, expansion of recruitment efforts for students such as posting flyers within highly-trafficked hallways where CURE classrooms are situated, and increasing overall interest through publication and outreach.

The study site is also restricted to a Hispanic-Serving Institution on the United States-Mexico border, so the findings may not be generalizable beyond this population. However, this survey is not specific to UTEP or its population and can easily be distributed to other institutions within the United States to evaluate and compare undergraduate experiences with and perceptions of RECR on a national scale.

Chapter 3: Factors that Impact the Scalability and Sustainability of Responsible and Ethical Conduct of Research (RECR) Education within Course-based Undergraduate Research Experiences (CUREs)

Introduction

Course-based undergraduate research experiences (CUREs) have been recognized as a promising environment to broaden participation in research, as they provide all enrolled students with the opportunity to experience a realistic impression of how research is actually conducted[9 16]. Despite continued emphasis on integrating RECR education within undergraduate curricula, however, current pedagogical resources, such as the "how-to" guide by the Council of Undergraduate Research, do not specifically address how to effectively integrate RECR education nor how to achieve scale or sustainability of this topic within the context of CUREs[21, 25]. Lack of guidance may also be attributed to the current CURE climate, as observed in a study conducted by Diaz-Martinez et al.[21], where CURE facilitators were surveyed about their experiences with integrating RECR within CURE curricula. While there was no shortage of enthusiasm among these facilitators regarding the need and value of RECR, attempts at integration appeared to be largely individualized. The main barriers cited were a lack of resources—such as time, funding, and available space[21, 58]—which further emphasizes the importance of creating baseline RECR activities and models that can be introduced and modified within and across CURE learning environments[3, 21].

The need to identify methods to scale up and sustain RECR education within CUREs has become a priority[31, 35] and remains unexplored in the literature. In response to this need, the current study expanded upon the work of Diaz-Martinez et al.[21] to specifically determine and describe factors that contribute to the scaling and sustainability of integrated RECR education within

CUREs. This study was also guided by prior literature regarding core RECR tenets and effective practices in the context of CURE instruction[48] as well as literature that evaluates the scalability of education interventions more generally[38]. Collectively, it was hypothesized that factors related to successfully scaling and sustaining RECR education within CUREs would include perceived importance, faculty buy-in, and identification of the "right time" to introduce RECR education. More acutely, this research project was guided by the following central questions:

1) What factors influence the extent to which RECR education can be scaled up and/or sustained within a CURE?
2) What implications might this have for the future integration of RECR within CUREs?

A mixed methods approach employing both quantitative and qualitative methodologies was employed, as described in the *Methods* section below. Through findings revealed within this study, I hope to provide novel and valuable insights into the factors that may influence the scalability and sustainability of integrated RECR education within CURE curricula to increase early exposure of undergraduate students to core RECR topics.

Methods

Participant Recruitment: Participants ($N = 7$; 78% of all eligible participants) included a convenience sample consisting of CURE stakeholders (e.g., faculty, staff, and administrators) who are actively involved in the development, implementation, and/or evaluation of CUREs in the biological sciences and/or (bio)chemistry at UTEP. Potential participants were recruited in the Spring 2023 semester via an e-mail announcement after first being identified as a CURE

stakeholder, which was accomplished by reviewing the posted, institution-wide course schedule and faculty/program websites. This project was approved by The University of Texas at El Paso's Institutional Review Board (IRB) under protocol ID# 1958705.

Scalability and Sustainability of RECR Survey and Interview: Prior to conducting interview procedures, a demographics questionnaire was deployed to collect general information about participants and their contact information **(Appendix B)**. Interview prompts were adapted from Zamboni et al.[38] and Kern[60], who previously evaluated factors related to the scalability and sustainability of professional development opportunities in CUREs. The adapted interview consisted of open-ended questions covering the following categories with the overall intent of identifying and describing factors related to the scalability and sustainability of RECR within CUREs: 1) attributes and credibility of the innovation/intervention; 2) importance and concerns; 3) advantages and disadvantages of adoption; 4) capacity to support scale-up and buy-in; and 5) timing or window of opportunity. Survey responses were analyzed using descriptive statistics (namely, frequency analyses)[41, 42]. Interview responses were blinded and each respondent assigned a pseudonym to protect their privacy and confidentiality. These data were then analyzed using a descriptive interpretive approach, in which prepared interview transcripts were qualitatively coded by two individuals (J.T.O. and K.A.S.) with expertise in biology education to identify emergent themes within the dataset. Exemplar quotes (e.g., case studies) and frequency statistics for each thematic category were also determined[22]. Iterative rounds of open and axial coding yielded high levels (>80.0%) of interrater reliability for each major theme **(Table 4)**, with all disputes resolved via discussion between the two coders.

Results

Respondent Demographics and Characteristics: Respondents (N = 7) predominantly self-identified as White and male (71.4% of respondents for each characteristic). Further, participants represented two categories of CURE stakeholders—faculty (71.4%) and staff (28.6%). These respondents reported varied experiences related to overall teaching (M = 23.4 semesters, s = 10.2), the teaching of laboratory courses (M = 14.6 semesters, s = 9.0), and providing mentorship within an academic capacity (M = 26.1 semesters, s= 11.0). They also reported experiences specifically related to the receipt of formal training about how to act as a mentor in a research setting (57.1%) and of formal pedagogical training about effective teaching practices in the context of RECR (42.9%).

CURE Stakeholder Perceptions of the Factors Associated with Scaling and Sustaining the Integration of RECR Education across CURE Curricula: Seven overarching themes were found during the interview coding process. These themes included multiple sub-themes that corresponded with the overarching themes. Twenty-six percent (26.0%) of the sub-themes were addressed by at least half (n = 4) of the total number of respondents (N = 7), with only one sub-theme addressed by all seven (7) respondents **(Table 4)**. Most of the interview responses exhibited high variability; therefore, only a few sample responses for each sub-theme that were articulated by at least half (n = 4) of the total respondents will initially be described below.

Table 4. CURE stakeholders' perceptions of the factors associated with the scalability and sustainability of RECR education within CUREs.

Themes	Sub-Themes	Total Faculty and Staff ($N = 7$)[a]
1. Value and benefit of RECR education	a. Dedicated time, space, and structure	2
	b. Preparedness for future research opportunities	7
	c. Knowledge & skills development	5
	d. Reduction in unethical practices	1
	e. Making informed personal decisions	2
2. Evidence for targeted RECR education within CUREs	a. Train-the-trainer needs	3
	b. Address student hesitancy	1
	c. Unique convention of CUREs	1
	d. Broad exposure to RECR	5
	e. Mitigating unethical behavior	1
	f. "If labs do it, so should CUREs"	1
3. Knowledge of existing RECR education opportunities	a. CITI	3
	b. Individualized per laboratory	2
	c. Existing programs	4
4. Applicability of RECR education beyond biology and (bio)chemistry CUREs	a. Societal impacts and trust in science	3
	b. Universal importance of RECR education	6
5. Faculty support for RECR education	a. Highlight importance to career/scholarly practice	1
	b. Evidence-driven approach	5
	c. Faculty incentives	1
	d. Intrinsic motivation	1
	e. Workload balance	2
	f. Accountability and standards	2
6. Challenges associated with RECR education	a. Administrative buy-in	3
	b. Lack of clear vision for implementation	1
	c. Apathy and/or lack of value	3
	d. Cutthroat nature of science	2
	e. Lack of time and resources	4
7. Timing of RECR education	a. Beginning of semester	6
	b. Middle of semester	3
	c. End of semester	3
	d. Repeat exposure	3

[a]Note that the value indicated in each cell represents the total number of participants whose responses included the subtheme indicated.

Theme 1 Highlights: Value and Benefit of RECR Education

Preparedness for future research opportunities: Notably, all stakeholders agreed that introducing undergraduate students to RECR education has great potential to teach a professional and ethical code of conduct and to foster mindfulness to subsequently prepare them for future challenges that may impact not only science, but society as a whole[14]. When asked about the value of RECR

education and preparing future generations of scientists, Brandon articulated the following sentiment:

> "I mean, the whole idea of having undergraduates work in a lab is to get them used to what the real world will be like if they were to go into research. And RECR is an integral component of any scientific endeavor under that matter."

Knowledge & skills development: Many stakeholders cited value in the development of knowledge and skills. Currently, STEM majors, such as those in biological science sub-disciplines, are not regularly exposed to concepts related to research ethics as part of their routine academic experience[18]. When asked about the value of RECR education in the development of knowledge and skills, Kippens described the following:

> "…I think it also gives them, in a lot of ways, more space to practice scholarship, to practice critical thinking, because when we're looking at RECR, we're asking ourselves at every step 'Are we doing the best we can? Are we being responsible with this? Are we setting a good pace for these things?'… So, you put yourself through these internal discussions, and that helps to reinforce a lot of the critical decision-making trees, the urge to go out and find more information, and expand your knowledge beyond your disiplin(ary) field."

Theme 2 Highlights: Evidence for Targeted RECR Education within CUREs

Broad exposure to RECR: Several participants noted the need for RECR education that prepared students for life beyond CUREs and/or their undergraduate academic experience, as demonstrated in the following quote by Hope:

> "I wouldn't say [that RECR education is needed] just in CUREs. I think in the undergraduate labs in general, the freshman labs, general biology labs. Even non-CURE labs, I think we should be delivering this [RECR education]. Because a lot of those students ultimately are going to end up in federally funded labs. Maybe when they're juniors, some as seniors. And the more students we can deliver this [RECR education] to, the better, right?"

Theme 3 Highlights: Knowledge of Existing RECR Education Opportunities

Existing programs: It is widely accepted that RECR education has value. However, opportunities to explore this topic at the undergraduate level remain few. When asked about knowledge of existing RECR opportunities at UTEP, Hope observed that:

> "There are opportunities for students to get exposure to RCR training but usually through some formal program like RISE (a federally-funded initiative). For the masses, there [aren't] opportunities and they're not really advertised for the broader, you know, student population."

Theme 4 Highlights: Applicability of RECR Beyond Biology and (Bio)chemistry CUREs

Universal importance of RECR education: Scientific integrity is often defined as "good citizenship applied to professional life," as this idea also extends to honesty, fairness, objectivity, openness, trustworthiness, and respect for others, which are more universal attributes[22, 23]. When asked about the applicability of RECR on a broader scale, Winsloe articulated the following:

> "I mean, anybody who does research needs to be responsible in their ethical guidelines when people are trying to learn new things. So, yes, within the construct of research that is being following in the liberal arts, be it history, be it political science… there are responsible conduct of research aspects; no plagiarizing, properly cite sources, try to not manipulate the primary sources of research."

Theme 5 Highlights: Faculty Support for RECR Education

Evidence-driven approach: In exploring recommendations to foster buy-in related to the support of RECR education, stakeholders described evidence-driven methods as the most effective. Kippens recommended:

> "Back it up with evidence to support the various outcomes from students and their performance in lab and courses."

Theme 6 Highlights: Challenges Associated with RECR Education

Lack of time & resources: Challenges related to time and resource availability, as frequently echoed in the literature as hurdles associated with the implementation of RECR education within undergraduate laboratory environments[21], were expressed by a number of participants. Brandon observed the following:

> "It's time and personnel. Faculty don't want to take the time. They would like someone else to do it for them. They agree that it needs to be done, but best if it's done on somebody else's nickel, so to speak."

Theme 7 Highlights: The "Right Time" to Introduce RECR Education

Beginning: Students are often described as being more curious, critical or logical, and more open to using the scientific method at the beginning of their academic careers[16]. Vaughan described the right time as:

> "But absolutely the training needs to be given at the beginning of the semester, because some people start their research and are already immersed in it before they come to know about RCR. Or as part of the CURE if they're given an opportunity to participate maybe as part of that, just like we do the EH&S (Environmental Health and Safety) training, CITI training, etc."

Stakeholders Revealed Perceived Value and Targeted Evidence to Support the Need for Providing RECR Training within Undergraduate Laboratory Environments: In this and all subsequent sections of this portion of the chapter, I provide a more comprehensive representation of the responses received by participants. First, when asked about what they perceived to be the value of providing responsible and ethical conduct of research (RECR) training within undergraduate laboratory environments, stakeholders predominantly cited the preparedness for future research opportunities (100% of responses; **Table 5**). This was followed by knowledge and skills development (71% of responses); dedicated time, space, and structure as well as making informed personal decisions—with these two themes reflecting equal response rates (n = 2; 29%

of respondents); and the reduction in unethical practices (14% of responses). Sample quotes that articulate these themes are presented in Table 5 below.

Table 5. Stakeholders' responses to the prompt: "Do you feel that it is valuable to provide responsible and ethical conduct of research (RECR) training within undergraduate laboratories?"

Theme: Dedicated Time, Space, and Structure	**Number of responses (%)[a]: 2 (29%)**
Sample Interviewee Responses: • "So, things like RCR, it's very important, I think, to have a uniform deployment across the students. And I think the CURE lab or a workshop in every department… it behooves us to do it through a professional setting, through a structured setting." • "When students can enroll in CUREs, and receive that training, it's sort of a dedicated time, and place, and space, and you have a little bit more control over assessing a narrative as opposed to just willy-nilly."	
Theme: Preparedness for Future Research Opportunities	**Number of responses (%): 7 (100%)**
Sample Interviewee Responses: • "…many of these students are eventually going to go on and be part of a federally funded lab, right. And the earlier we can get them with these things [RECR education], the better." • "I think, the earlier you start training students on those ethical values of researchers, the better off they are later on."	
Theme: Knowledge + Skills Development	**Number of responses (%): 5 (71%)**
Sample Interviewee Response: • "Yes, it [RECR education] is extremely valuable, especially for institute(s) like ours, or where the students are quite unaware of what research really is."	
Theme: Reduction in Unethical Practices	**Number of responses (%): 1 (14%)**
Sample Interviewee Response: • "So, I think it [RECR education] will definitely prevent them from getting into trouble, and maybe things like plagiarism."	
Theme: Making Informed Personal Decisions	**Number of responses (%): 2 (29%)**
Sample Interviewee Responses: • "And many of the concepts that we can present as part of training in research ethics is – have to do with regular life and responses to situations that have nothing to do with research." • "I think ethics is important in any facet of life. Not just being an ethical scientist but being an ethical person. Even in personal life, not just professional life."	

[a] $N = 7$; participant responses were coded into multiple categories, as appropriate.

When asked about the academic environment and whether there is evidence to support the need for targeted RECR education within CURE curricula, as perceived based on their prior experiences, stakeholders primarily cited the need for broad exposure to RECR (71% of responses; **Table 6**), followed by train-the-trainer needs (43% of responses). Evidence less cited included addressing student hesitancy, the unique conventions of CUREs, the mitigation of unethical

behavior, and the idea that "If labs do it, so should CUREs"; with these four themes reflecting equal response rates (n = 1; 14% of respondents). Sample quotes that illustrate these themes are presented in Table 6 below.

Table 6. Stakeholders' responses to the prompt: "Do you feel there is evidence to support the need for targeted RECR education within CURE curriculum, in particular?"

Theme: Train-the-Trainer Needs	**Number of responses (%)[a]: 3 (43%)**
Sample Interviewee Responses: • "I think more specific individuals within departments that you know are buying into this [RECR education] to say, hey, would you bring this up at a faculty meeting and let's start a discussion." • "Cause there's training the trainers, and then there's figuring out how you want students trained as well. And both of those are really critical aspects. So, [for instance], making sure your TAs know what to do in a given situation, and how to convey that effectively to students, is a huge part of the conversation."	
Theme: Address Student Hesitancy	**Number of responses (%): 1 (14%)**
Sample Interviewee Response: • "But when it comes to the lab, I think they [students] are so afraid of making mistakes, owning up to them, afraid of the consequences, afraid of failing, afraid of looking dumb in front of their peers or mentors, trying to make a good impression. And trying to figure out how do we give them an environment and set the ground rules where they have a standard operating procedure in place for those mistakes."	
Theme: Unique Conventions of CUREs	**Number of responses (%): 1 (14%)**
Sample Interviewee Response: • "…if a CURE, or the research-based course that one is offering, deals with animal experimentation, [for instance], some responsible culture research description with regard to animal welfare must be covered, has to be. Of course, we (the respondent's CURE) don't do animal experimentation, so it is not pertinent in my lab to actually discuss that."	
Theme: Broad Exposure to RECR	**Number of responses (%): 5 (71%)**
Sample Interviewee Responses: • "Perhaps a general classroom like the science labs that we have here at UTEP that should include also responsible culture research discussion that is general and broad, that is non-targeted." • "I think CURE type of courses are also very thought-provoking, critical thinking provoking, in a way that even if the student doesn't go in traditional route of doing research, which many of them don't after they take the CUREs, I think it still benefits them to be exposed to understanding what research is."	
Theme: Mitigating Unethical Behavior	**Number of responses (%): 1 (14%)**
Sample Interviewee Response: • "They [students] end up using somebody else's application materials, or interim materials, or even some of their data to apply for either the FYRIS [program or] all of these undergraduate research labs without thinking that originally belonged to somebody else who preferred to write it from scratch. Because it's very convenient to appropriate somebody else's work. And then, once you start doing that, it becomes very easy for you to do that continually."	
Theme: "If Labs Do It, So Should CUREs"	**Number of responses (%): 1 (14%)**
Sample Interviewee Response: • "I mean, I think this is one of the most valuable trainings that you can provide a student that may end up being a researcher in the future. And you know when they start doing research as part of a course, it's the same as if they were doing research as part of a mentor research group. I think it's, regardless of the means or the mode in which the student does research, they need to be exposed to this [RECR education]."	

[a]N = 7; participant responses were coded into multiple categories, as appropriate.

Stakeholders' Awareness of Existing RECR Programs or Opportunities Within Their Departments, Colleges, or the Overall Institution: When asked about their awareness of existing RECR programs or opportunities, stakeholders cited existing undergraduate research experience-oriented programs (57% of responses; **Table 7**), followed by the web-based Collaborative Institutional Training Initiative (CITI) program (43% of responses) and individualization per laboratory (29% of responses). Sample quotes that illustrate these themes are presented in Table 7 below.

Table 7. Stakeholders' responses to the prompt: "To your knowledge, what type of RECR programs or opportunities currently exist within your department or college, if any?"

Theme: CITI	**Number of responses (%)[a]: 3 (43%)**
Sample Interviewee Responses: • "That I'm aware of, minus the required RCR training that we're required to do as a funded scientist for example that I do every so often on CITI – on the CITI website, right. And as far as our students go, no." • "So, the only ones that I know about are of course a city training that the university requires of every researcher to take (CITI). And the training that we provided for you on responsible conduct of research to as many students in our programs (EP) as we can." • "It's CITI or bust."	
Theme: Individualized per Laboratory	**Number of responses (%): 2 (29%)**
Sample Interviewee Responses: • "I think any student who comes to my lab, even if it's volunteer work for a few hours, I send them first to take those before anything else. They cannot even come to the lab doing anything without, that's the first step." • "To my knowledge within the department, I guess, it's individualized per research groups (I). So, when students have access to a research laboratory some of these discussions are discussed within each research group. For instance, I have a laboratory manual which we discuss many things, including proper ethical conduct, but I don't know if there is, or as far as I know, there is not an institutionalized course at the department level."	
Theme: Existing Programs (e.g., RISE, MARC)	**Number of responses (%): 4 (57%)**
Sample Interviewee Responses: • "Awhile ago we used to have MARC program, the MARC program itself that was also university level." • "So, the ones I would have, would be through the office of COURI. And I know that there are online." component which I confess I don't think are the best way to go for undergrads. I'm not sure they're the best way to go for faculty. But they're easy to do for faculty and so they tend to be emphasized."	

[a]*N* = 7; participant responses were coded into multiple categories, as appropriate.

Stakeholders' Responses Regarding the Applicability of Expanding RECR Education Beyond Biological Science and (Bio)chemistry CUREs: When asked about expanding current

CURE programming to other STEM-related CUREs, stakeholders predominantly cited the universal importance of RECR (86% of responses; **Table 8**), followed by societal impacts and trust in science (43% of responses). Sample quotes that illustrate these themes are presented in Table 8 below.

Table 8. Stakeholders' responses to the prompt: "Do you think there would be community support if current CURE programming were expanded to support other STEM CURE courses?"

Theme: Societal Impacts and Trust in Science	**Number of responses (%)[a]: 3 (43%)**
Sample Interviewee Responses: • "At the end of the day, we're still looking at how do we provide the public with an accounting of what we've done? And how do our practices impact the public at large? So, whether you're dealing with transgenic mice or looking at GMOs and making sure that they're not escaping into the broader population of plants, of if you're looking at collecting data to say that disparities arise due to factors X, Y, and Z, we need to address this as a society." • "Lack of trust in science in the past couple of years, it's my perception, that has increased dramatically. People don't believe in vaccines; people don't believe in climate change; people are skeptical at scientists. And all of that is not because of the scientists themselves, it's because of politics, but some part of that is also because of unethical scientific practices. …So, of course, having a broad responsible conduct in research education [may] help familiarize those issues."	
Theme: Universal Importance of RECR Education	**Number of responses (%): 6 (86%)**
Sample Interviewee Response: • "The environment and the way research [are] done in different areas can be drastically different. And so, responsible and ethical conduct of research training might look different in those settings. But I think it's still highly important that things are done in an ethical and responsible way, right?"	

[a]*N* = 7; participant responses were coded into multiple categories, as appropriate.

Stakeholder Recommendations on How to Encourage Faculty Participation in and Support for RECR: When prompted to reflect on what they believed might encourage faculty to participate in and support RECR education, stakeholders predominantly cited an evidence-driven approach (71% of responses; **Table 9**). This was followed by workload balance and accountability and standards—with these two themes obtaining equal response rates (*n* = 2; 29% of respondents). Recommendations less cited included highlighting the importance to career/scholarly practice, faculty incentives, and intrinsic motivation—with these three themes reflecting equal response

rates (n = 1; 14% of respondents). Sample quotes that illustrate these themes are presented in Table 9 below.

Table 9. Stakeholders' responses to the prompt: "How might faculty encourage and support participation in RECR education?"

Theme: Highlight Importance to Career/Scholarly Practice	**Number of responses (%)[a]: 1 (14%)**
Sample Interviewee Response: • "Getting these professors to recognize that these types of exchanges [i.e., conversations about RECR practices] are not only something that's going to help develop these students through their courses for their career long-term; it's also honing their skills as scholars."	
Theme: Evidence-Driven Approach	**Number of responses (%): 5 (71%)**
Sample Interviewee Responses: • "You would have to persuade the faculty that this [RECR education] is valuable." • "[Faculty adoption] will depend on the effectiveness of the proposed initiatives. The perceived effectiveness, I guess." • "By presenting cases to them [faculty]. Real cases. Not necessarily fictitious but real cases, which are out there in the literature of things that have happened."	
Theme: Faculty Incentives	**Number of responses (%): 1 (14%)**
Sample Interviewee Response: • "Here's either some time off, a buyout of other teaching responsibilities to develop this [RECR education], or here is a person on staff that you can go to and work with to help you design a course with these things baked in. Here's some money that you can throw towards this, or here is some sort of incentive fund for engaging in this conversation."	
Theme: Intrinsic Motivation	**Number of responses (%): 1 (14%)**
Sample Interviewee Response: • "I'm optimistic of all my colleagues in the sense that they are all willing to pursue and further responsible conduct of research within the ranks, and through the school department groups, and society."	
Theme: Workload Balance	**Number of responses (%): 2 (29%)**
Sample Interviewee Responses: • "If you were to tell me, 'Here, there's a bunch of topics that I think you should cover in your FYRIS course, and make sure you talk about this every so often,' I'll probably say, "Thank you" and then I would just probably not pick up the phone again. It's directly related to the workload, right?" • "And so, I think I certainly see the value of RCR, but it needs to be done in a way, it shouldn't seem like another long assignment for them [faculty] because that time is gone."	
Theme: Accountability & Standards	**Number of responses (%): 2 (29%)**
Sample Interviewee Responses: • "I think it needs to be required." • "So, it should be absolutely top down, faculty down to the student. And then, the student also should involve the faculty, maybe debrief in a group meeting what they learned from RCR simply because maybe the graduate students, especially if they come from abroad due to some cultural differences, or this rat race to publish. But they may not be aware of some of the themes that are really important. So, absolutely, faculty should buy in."	

[a]N = 7; participant responses were coded into multiple categories, as appropriate.

Stakeholders' Perceptions of Challenges and Obstacles Related to the Sustainability and Scalability of RECR Education: When asked about what they perceive to be the challenges and obstacles associated with scaling up and sustaining RECR education within CURE curricula, stakeholders largely cited lack of time and resources (57% of responses; **Table 10**). This was followed by administrative buy-in and apathy and/or lack of value—with these two themes reflecting equal response rates (n = 3; 43% of respondents). Challenges and obstacles less cited included the cutthroat nature of science (29% of responses) and a lack of clear vision for implementation (14% of respondents). Sample quotes that illustrate these themes are presented in Table 10 on the subsequent page.

Table 10. Stakeholders' responses to the prompt: "What do you perceive to be the challenges/obstacles associated with the scalability and sustainability of RECR education?"

Theme: Administrative Buy-In	**Number of responses (%)[a]: 3 (43%)**
Sample Interviewee Responses: • "So, increased red tape, there's always that fear that, 'Man, that's another thing that we need to keep track of now.' So, increased red tape and increase bureaucracy leads to… So, extra bureaucratic steps may actually be another issue." • "I think that the challenge is, to this, in general are organized administration that exhibits buy in. So, if you are in your own little CURE in your own little universe, it's fairly easy to maintain these principles for 24-48 students in a class. Once you start looking at trying to thread your way through a program, you have to determine as a department, or as a committee of people, that these are the principles we want our students to walk away with."	
Theme: Lack of Clear Vision for Implementation	**Number of responses (%): 1 (14%)**
Sample Interviewee Response: • "And then, people just sort of have these haphazard ideas of what that [RECR education] looks like, and you get this sort of spotty implementation because there's no clear vision as far as how all of this is going to hang together."	
Theme: Apathy and/or Lack of Value	**Number of responses (%): 3 (43%)**
Sample Interviewee Responses: • "Getting people to adopt it and take it seriously, right? …And I think RECR is just another one of those areas that we don't get a lot of pressure to put time into because it's not that training that's going to get us promoted in the future and things like that." • "If you asked them [students] would you do this, or that, or whatever, they're not so excited to go about a CITI module or RCR."	
Theme: Cutthroat Nature of Science	**Number of responses (%): 2 (29%)**
Sample Interviewee Responses: • "So, because of the nature of science, and the pressures, and the time commitments and things, we've put a lot of things on the back burner, and we ignore a lot of things. And I think RECR training and even safety training and stuff like that is not taken as seriously as it should be." • "Some faculty may not care about this RCR simply not because they wanna violate it… they want to publish first without necessarily looking at all the literature that's already out there. Or they might be using students to compete against one another where one student does obtain some data, and another student, unbeknownst to the first student, and unbeknownst to the second student, is repeating the same experiment just to increase the end value."	
Theme: Lack of Time & Resources	**Number of responses (%): 4 (57%)**
Sample Interviewee Response: • "Time is money, and you know faculty mentors have a tendency – I'm sorry, research group meetings are 2% research and nothing else. And these topics are not necessarily – they don't have enough time to get engaged in these topics."	

[a]*N* = 7; participant responses were coded into multiple categories, as appropriate.

Stakeholders' Perceptions of the "Right Time" to Introduce RECR Education: When prompted to reflect on what they perceived to be the "best time" to introduce RECR education within CUREs, stakeholders primarily indicated that the beginning of the CURE is the "best time" (86% of responses; **Table 11**). This was followed by the middle, end of semester, and repeated

exposure as the "best times"—with these three themes reflecting equal response rates (n = 3; 43% of respondents). Sample quotes that illustrate these themes are presented in Table 11 below.

Table 11. Stakeholders' responses to the prompt: "At what point of the semester should RECR be presented within a CURE?"

Theme: Beginning of Semester	**Number of responses (%)[a]: 6 (86%)**
Sample Interviewee Responses: • "Probably right at the beginning." • "And the answer is the beginning. This is – it's a fundamental part. You know, if you're not willing to do this or if you're not willing to take it seriously, you don't belong in a lab that is doing real research."	
Theme: Middle of Semester	**Number of responses (%): 3 (43%)**
Sample Interviewee Responses: • "It might be better to let them get some exposure to the first semester's research and start thinking like scientists and then do it at the midway point." • "So, I think they need to be exposed a little to their research before. So, probably mid to end of the semester would be best".	
Theme: End of Semester	**Number of responses (%): 3 (43%)**
Sample Interviewee Responses: • "…then have a follow-up at the end of the semester. Where the follow-up would be where they've been able to apply, report out where they may have applied their newfound training and knowledge through the semester, right?" • "It definitely does depend on the class, but looking at my class, and most class structure, I feel this would be better to introduce towards the end of the semester, mid to end of the semester, not in the beginning of the semester."	
Theme: Repeat Exposure	**Number of responses (%): 3 (43%)**
Sample Interviewee Responses: • "…when you're actually doing research, you need to be exposed regardless of what time you are at." • "Bang on the dot day one, and you keep doing it every day thereafter."	

[a]N = 7; participant responses were coded into multiple categories, as appropriate.

Discussion and Limitations

The factors associated with successful scalability and sustainability of RECR education within CUREs have remained wholly unexplored and was the focus of the proposed research. Notably, the sub-themes revealed by interviewees exhibited high variability. However, this could be largely attributed to the current landscape of RECR education within undergraduate laboratory environments, particularly CUREs[21]. Although there is an abundance of RECR programs that are available, these often differ considerably in goals, scope, content, and approach due to lack of

guidance on how to effectively integrate and assess outcomes associated with such training[8, 15, 23]. Instruction of RECR education in undergraduate laboratory environments continues to be neglected, informal, or intermittent[14]; however, the value and benefit of integrating RECR education within the curricula was largely shared between interviewees, with preparedness for future research opportunities at the forefront and the development of lifelong knowledge and skills closely behind. It is worth nothing that stakeholders predominantly identified as White and male, whereas students predominantly identified as Latino/Hispanic and female. It is unclear if the differences in cultural backgrounds and/or demographic characteristics may affect how these groups perceive the value of ethics in the context of scientific endeavors—an area that should be followed up on in future investigations.

Engaging both scientists and non-scientists in the discussion of RECR from the very beginning of their routine academic experiences can lead to the development of conscious thinking about ethics, an increased understanding of the scientific process, and public trust[14]. That being said, opportunities to receive meaningful RECR education remain few, as many existing, yet highly-competitive, undergraduate research experiences, such as the NIH-funded Research Initiative for Scientific Enhancement (RISE), often lack the necessary resources to involve all or even most students[21, 23]. This supports a need for increased integration of RECR within undergraduate laboratory environments, with CUREs at the forefront due to their open accessibility and lack of requirement for previous research experiences[33].

While RECR tenets are applicable to all fields and disciplines, the extent to which they are followed and applied varies[10, 22, 49]. Notably, interviewees cited the importance of applying RECR tenets universally, as all endeavors (scientific or not) should be conducted in an ethical and responsible way. Therefore, CUREs could further serve as a platform to provide baseline RECR

education to all students as early as the freshman level, as there is increasing evidence to demonstrate that CUREs positively impact student perceptions about the research process[24].

However, future studies are needed in this area. RECR education primarily begins after graduation at the post-baccalaureate level, as many instructors continue to forego RECR instruction due to a lack of shared RECR pedagogical resources or a lack of time or finances to develop such resources[4, 18, 21]. Therefore, the need to further explore mechanisms related to scaling and sustaining RECR education opportunities is necessary to not only increase exposure to these ethical ideas but also to teach a professional code of conduct and practice and to foster mindfulness that can last a lifetime[14].

Several limitations must also be considered when interpreting this work. The number of participants who completed the interview was limited and was not completely representative of the community of stakeholders at UTEP (e.g., graduate teaching assistants involved with the CUREs were unable to be recruited). This may yield an incomplete picture about how to effectively achieve scale and sustainability of RECR education and likewise limit the generalizability of the study findings, although this research was designed as a case study. Additionally, there is a possibility that the timing of the e-mail recruitment announcement resulted in low participation, as it was distributed toward the end of the semester and close to final exams, which may not have been ideal due to increased grading responsibilities during this time. There may have also been issues with the recruitment strategy given that it was e-mail based, and those e-mails could have been lost within eligible participants' inboxes, as stakeholders are often inundated with other correspondence due to their professional roles.

Strategies to overcome these challenges in the future include increasing the number of rounds of e-mail announcements, expansion of recruitment efforts by asking department chairs or college

deans to forward recruitment correspondence—to include in-person recruitment by visiting eligible participants' designated office and laboratory spaces—and increasing overall interest through publication and outreach. As previously alluded to, the study site was restricted to a Hispanic-Serving Institution on the United States-Mexico border, so the findings from CURE stakeholders may not be generalizable beyond this population. However, as this activity is not UTEP-specific, it can easily be conducted with other CURE stakeholders across the United States to identify the factors that impact the scalability and sustainability of RECR education on a national scale.

Chapter 4: Overarching Discussion and Recommendations

Undergraduate research experiences (UREs) have been viewed as an integral environment to train future generations of scientists[33]. However, this environment often lacks adequate resources[4, 10, 21] to involve all or even most matriculated students as part of their routine academic experience[15]. In an effort to expand accessibility to authentic research experiences, CUREs have emerged as an inclusive platform to immerse all students in the process of scientific discovery[24, 33], with primary exposure beginning at the freshman level[15, 33]. In the pursuit of scientific endeavors—whether in a CURE or elsewhere—one fundamental component of the process involves the ability to conduct research ethically and responsibly[9, 17]. Responsible and ethical conduct of research (RECR) education is currently the primary strategy to convey instruction related to responsible and ethical research practices[10, 17]; however, guidance on how to effectively apply RECR education to achieve intended gains in RECR knowledge, skills, and dispositions remains unclear[8, 36].

In exploring how to effectively incorporate RECR education into undergraduate laboratory curricula, experts in RECR have articulated that integrated training should focus not only on building knowledge but also on increasing awareness about potential ethical dilemmas that may be encountered[23]. Studies that specifically explore approaches on how to successfully integrate RECR education within the context of CUREs remain few[21]. However, general approaches applied within undergraduate laboratory environments have typically involved a combination of passive or active strategies, to include active learning techniques such as roleplay[5]. To this end, the exploration and use of active learning approaches through gamification and game-based learning (GBL) is recommended as one potential approach to achieve scalability and sustainability of RECR education across CURE curricula.

The application of gamification has been used to teach a variety of subjects, ranging from business[65] to STEM[61, 66], and incorporates game design elements, gameplay mechanics, and game-based thinking within non-game contexts to foster engagement and encourage problem-solving[67]. Within gamification lives game-based learning, but this specifically refers to the use of game design within educational contexts[65, 68], with strategy-based design referred to as "serious games."[61] Based on findings by Rowe[64], who utilized interactive story scenarios to convey educational content, the integration of GBL can further promote the development of intrinsic motivation[61, 68]. Furthermore, students tend to experience greater learning gains and increased problem-solving performance, regardless of prior knowledge or gaming experience, due to increased engagement within inquiry-based learning environments[64].

As a lack of resources has routinely been cited as a barrier to the implementation of effective RECR instruction[21], some recommended strategies that do not require substantial resources from stakeholders and that can be conducted during "down time" in the laboratory include roleplay and/or debate of an ethical case study[18]. Use of roleplay and/or debate through the exploration of real-world problems and situations[68] can result in an enhanced learning experience[37] by allowing students to consider multiple positions that may cause them to re-evaluate their attitudes and behaviors[18] about responsible and ethical research practices. Use of these activities can also positively contribute to the development of life-long skills[25], such as problem-solving, communication, and collaboration[61].

Complementary to the CURE hallmarks previously described by Auchincloss et al.[15], if lack of resources is not an immediate obstacle, stakeholders could consider developing and implementing serious games, such as a novel escape room-based activity, due to their appealing design flexibility (i.e., they can be continuously modified according to the needs and desired

learning outcomes of the curriculum[67, 69, 70]). Notably, use of serious games has been shown to increase motivation and engagement while fostering the development of teamwork and communication skills through the discovery of clues, solving of puzzles, and (often) the shared goal of accomplishing tasks in a limited amount of time[52, 65, 70]. Use of serious games such as escape rooms can also provide students with an immersive experience and opportunities for engagement in teamwork, creativity, decision-making, leadership, communication, and critical thinking[52, 67].

Therefore, integration of GBL activities, such as the exploration of case studies through roleplay or through novel approaches such as escape rooms within CUREs, may be an effective way to integrate RECR instruction and achieve scalability and sustainability across the CURE curricula. Ideally, this will result in increased numbers of students receiving formal and purposeful RECR education prior to graduation by providing them with the opportunity to develop an awareness of how to navigate convoluted RECR-related issues, such as grey dilemmas, and to be ethically-minded citizens.

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Appendices

Appendix A: Perceptions and Experiences of Responsible and Ethical Conduct of Research (RECR) Survey

University of Texas at El Paso (UTEP) Institutional Review Board
Informed Consent Form for Research Involving Human Subjects

Protocol Title: Exploring Undergraduate Researchers' Experiences and Perceptions of Responsible and Ethical Conduct of Research (RECR) Education in Biological Sciences and Chemistry
Project Investigators: Jeffrey T. Olimpo, Ph.D. (jtolimpo@utep.edu) and Bernice Caad, B.Sc. (bcaad@utep.edu)
UTEP: Department of Biological Sciences, B226A Biology Bldg.
Funding: Self-Funded

NOTE: In this consent form, "you" always means the study subject. If you are a legally authorized representative, please remember that "you" refers to the study subject.

Introduction

You are being asked to take part voluntarily in the research project described below. You are encouraged to take your time in making your decision. It is important that you read the information that describes the study. Please ask the study researcher or the study staff to explain any words or information that you do not clearly understand.

Why is this study being done?

You have been asked to take part in a research study that seeks to examine student experiences and perceptions of responsible and ethical conduct of research (RECR) education within faculty-mentored research laboratories and course-based undergraduate research experiences (CURE) in the biological sciences or chemistry. Furthermore, this research seeks to provide additional insights into the effective incorporation of RECR education within CURE curricula.

Approximately 550 students will be asked to enroll in this study at UTEP.

You are being asked to be in the study because you are:

- Currently an undergraduate student at UTEP; **and**
- At least 18 years of age; **and**
- Are currently or have been previously enrolled in a CURE course within a biological sciences or chemistry discipline; **and/or**
- Are currently or have been previously engaged in faculty-mentored research within a biological sciences or chemistry discipline.

If you decide to enroll in this study, your involvement will last the duration of the semester in which you voluntarily consent to participate in the study. Specifically, you will be asked to provide survey data and will be invited to participate in one brief, semi-structured interview to learn more about your experiences and perceptions of RECR education within faculty-mentored research and/or CURE contexts. Your involvement in these procedures is expected to last 60 – 70 min. in duration.

What is involved in the study?

If you agree to take part in this study, the research team will:

- Address any questions or concerns that you might have about this consent document and briefly provide a verbal description of the research study.
- Ask for your cooperation to complete a 30- to 40-minute survey designed to explore your perceptions and experiences with RECR.
    - If you are enrolled in a CURE course, you will be asked to complete the survey twice. Once after the Fall semester has ended and once after the Spring semester has ended.
    - If you are only engaged in faculty-mentored research, you will be asked to complete the survey once after the semester has ended.
- Invite you to participate in a 30-minute, audio/video-recorded, semi-structured interview designed to provide additional detail regarding your perceptions and experiences with RECR in the context of CUREs and/or faculty-mentored research.
    - Interviews conducted in person will be audio-recorded using a separate audio-recording device, whereas interviews conducted virtually over Zoom will be audio- and video-recorded through the conferencing software.
    - If interested, you will be asked to provide your e-mail at the end of the survey for potential follow-up.
- Ask, at the end of the survey, if you are interested in being re-contacted by e-mail regarding future RECR research opportunities.

What are the risks and discomforts of the study?

There is minimal risk associated with participation in this study. You may become self-conscious while completing the survey or while being audio- or videotaped. You may request that the research team cease collection of audio- and/or video-data at any point throughout the duration of the study or stop at any time with no repercussions or penalty (e.g., loss of program status). As the study involves the use of audio/video-recorded interviews, if you consent to participate in

this portion of the study, there is the possibility that you may experience a loss of privacy and confidentiality due to the nature of the research environment. To minimize these risks, the audio- and/or video-taped data will only be shown in settings for professional educators and scientists (e.g., professional meetings or conferences; laboratory research meetings), and, in all cases, you will be referred to by a pseudonym.

Are there benefits to taking part in this study?

There are no guaranteed benefits to you. However, this research is intended to provide valuable insights into the experiences and perceptions of RECR education of undergraduate students within biological science and chemistry disciplines to improve the delivery and integration of RECR within the CURE curriculum, with possible extension to faculty-mentored research spaces.

What are my costs?

There are no direct costs.

Will I be paid to participate in this study?

At the end of the survey(s), you will be invited to enter your e-mail into a drawing for one (1) of four (4) $25 gift cards as a "thank you" for your time and effort. Entry into the drawing is entirely optional. If your name is drawn, your gift card will be sent to the e-mail address that you provided at the end of the survey.

If you indicate interest and are invited to participate in the semi-structured interview, you will be given a $10 gift-card as a "thank you" for your time and effort. Your gift card will be sent to the e-mail address that you provided at the end of the interview.

What other options are there?

You have the option not to take part in this study. There will be no penalties involved if you choose not to take part in this study. Choosing to withdraw or not participate will not affect your grades, nor your program or university standing.

What if I want to withdraw, or am asked to withdraw from this study?

Taking part in this study is voluntary. You have the right to choose not to take part in this study. If you do not take part in the study, there will be no penalty or loss of benefit. If you choose to take part, you have the right to skip any questions or stop at any time. However, we encourage you to talk to a member of the research group so that they know why you are leaving the study. If there are any new findings during the study that may affect whether you want to continue to take part, you will be told about them. The researcher may decide to stop your participation without your permission if he or she thinks that being in the study may cause you harm.

Please note that if you initially elect to participate in the study but later choose to withdraw from the study or are removed from the study, any data that you provided will not be included in any part of the analysis or dissemination phases of the project. In the event that you would like to withdraw from the study, please contact the project PI, Dr. Jeffrey Olimpo, at jtolimpo@utep.edu or Bernice Caad at bcaad@utep.edu. Please note, however, that once your data has been de-identified and can no longer be linked to you, the research team will not be able to remove your data from the study.

Who do I call if I have questions or problems?

You may ask any questions you have now. If you have questions later, you may contact **Dr. Jeffrey Olimpo** at **phone:** (915) 747-6923**; e-mail:** jtolimpo@utep.edu or **Bernice Caad** at **e-mail:** bcaad@utep.edu . If you have questions or concerns about your participation as a research subject, please contact the UTEP Institutional Review Board (IRB) at (915) 747-8841 or irb.orsp@utep.edu.

What about confidentiality?

To maintain the confidentiality of your records, any audio- and/or video-recordings collected with your consent will be stored in a locked filing cabinet in the office of PI, Dr. Jeffrey Olimpo (B226A Biology Bldg.); electronic or paper artifacts (such as survey data) will be stored as password-protected files on Dr. Olimpo's password-protected workstation (housed in B226A, Biology Bldg.) **and/or** as encrypted, password-protected files on the Microsoft OneDrive platform sanctioned by the university in accordance with all mandatory policies and procedures. Survey data, recordings, and identifiers will be accessible only by trained members of the research team and only for the purposes of coding, qualitative data analysis (e.g., identifying themes in participant responses across the dataset), and quality control (e.g., bot verification and consolidation of duplicate responses). Upon completion of transcription, data analysis, and reporting, your audio- and video-recordings will be immediately destroyed. Please note that if a quote from you is presented (e.g., at a research conference or publication), you will be referred to by a pseudonym to maintain your confidentiality. All identifiable data will be retained for a period of 5 years, before being de-identified and destroyed. De-identified data, that cannot and will not be linked back to you, will be retained indefinitely.

Every effort will be made to keep your information confidential. Your personal information may be disclosed if required by law. Please also note that the following organizations may request to inspect and/or copy your research records for quality assurance and data analysis:

- Office of Human Research Protections
- UTEP Institutional Review Board

Because of the need to release information to these parties, absolute confidentiality cannot be guaranteed. Relatedly, you may be contacted (via e-mail) by PI Olimpo or Co-PI Bernice Caad if they are required to do so by law or in the event that further clarification is needed from you.

Authorization Statement

I have read each page of this paper about the study (or it was read to me). I know that being in this study is voluntary and I choose to be in this study. I know I can stop being in this study without penalty. I know that I can print off a copy of this consent form to keep or request a copy from the research team at a later date.

_____
Participant's Name (printed)

_____ _____
Participant's Signature Date

_____ _____
Participant's Student ID # (Quality Control) Date

_____ _____
Signature of Person Obtaining Consent Date

If you are selected to participate in the semi-structured interview process, do you provide consent to be video- and/or audiotaped during that interview? (Please check the appropriate line below)

☐ Yes, I provide consent to be video- and/or audiotaped during my participation in the interview.

☐ No, I do not provide consent to be video- and/or audiotaped during my participation in the interview.

Please provide your current student status (e.g., freshman, senior).

☐ Freshman ☐ Senior
☐ Sophomore ☐ Other (e.g., post-bacc): _____
☐ Junior

Please select your major from one of the choices below.

☐ Biological Sciences ☐ Neuroscience
☐ Chemistry ☐ Microbiology
☐ Cell and Molecular Biochemistry (BIOL - CBCH) ☐ Biochemistry (CHEM)
☐ Ecology and Evolutionary Biology ☐ Other: _____

Do you identify as an international student?

☐ Yes ☐ No

Is English your first language?

☐ Yes ☐ No

How would you describe your current research and/or laboratory experiences? Please select all that apply.

NOTE: *CUREs are course-based undergraduate research experiences, which offer a platform to engage students in authentic scientific investigations through active involvement in the development of their own research questions, methods, data analysis, and the communication of findings. (For example: FYRIS-BUILD, Phage Hunters with Dr. Rosas-Ascosta, or Brain Mapping with Dr. Khan).*

☐ CUREs, with no faculty-mentored research experience

☐ CUREs, with faculty-mentored research experience

☐ Faculty-mentored research, with no CUREs experience

☐ Other: _____

How many **semesters** of undergraduate research experience, if any, do you have? _____

How many **semesters** of CURE experience, if any, do you have? _____

What is your race/ethnicity?

☐ American Indian or Alaska Native

☐ Asian

☐ Black or African American

☐ Native Hawaiian or Other Pacific Islander

☐ Latino/Hispanic

☐ White

☐ Multi-racial/Multi-ethnic

☐ I prefer not to indicate

☐ I prefer to self-describe: _____

With what gender do you identify?

☐ Male ☐ Non-binary

☐ Female ☐ I prefer not to indicate

In general, how would you describe your current level of training in responsible and ethical conduct of research (RECR)?

☐ None

☐ Moderate (a required workshop or seminar)

☐ High (multiple workshops and/or seminars)

☐ Extensive (a full-semester course on ethics in research)

☐ Other: _____

For each of the following experiences, please indicate the extent to which formal responsible and ethical conduct of research (RECR) education was a part of that experience. *If you did not experience this training, check N/A for non-applicable.*

	Never	*Rarely*	*Sometimes*	*Often*	*Most of the Time*	*Always*
CUREs	☐	☐	☐	☐	☐	☐
Faculty-Mentored Research	☐	☐	☐	☐	☐	☐

In addition to in-class or program-required responsible and ethical conduct of research (RECR) training, have you participated in any of the following? *Please select all that apply.*

☐ Institutionally sponsored training seminars, workshops, or training modules
☐ Online training modules (not offered through your institution)
☐ Workshops/seminars (not offered through your institution)
☐ None of the above

In the context of the experiences noted below, have you ever <u>encountered or had to resolve</u> responsible and ethical conduct of research (RECR) issues with respect to the following topics? *Please select all that apply for both experiences.*

	CURE(s)	**Faculty-Mentored Research**	**Neither Experience**
<u>Collaboration</u> *(including professional conduct and communication)*	☐	☐	☐
<u>Ownership</u> *(including project data)*	☐	☐	☐
<u>Authorship</u> *(including responsible communication, author order)*	☐	☐	☐
<u>Research misconduct</u> *(including falsification and/or fabrication of data, issues in record-keeping, or other protocol-specific concerns)*	☐	☐	☐
<u>Data management</u> *(including sharing, collection, preservation, and ownership)*	☐	☐	☐
Mentor/instructor/student responsibilities	☐	☐	☐
<u>Privacy and protection(s)</u> *(human, private health information, recombinant DNA, animal ethics considerations)*	☐	☐	☐
Reporting and publications	☐	☐	☐
General laboratory safety	☐	☐	☐

In the context of the experiences noted below, have you ever <u>been provided specific training</u> in the following topics? *Please select all that apply for both experiences.*

	CURE(s)	Faculty-Mentored Research	Neither Experience
Collaboration *(including professional conduct and communication)*	☐	☐	☐
Ownership *(including project data)*	☐	☐	☐
Authorship *(including responsible communication, author order)*	☐	☐	☐
Research misconduct *(including falsification and/or fabrication of data, issues in record-keeping, or other protocol-specific concerns)*	☐	☐	☐
Data management *(including sharing, acquisition, preservation, and ownership)*	☐	☐	☐
Mentor/trainee responsibilities	☐	☐	☐
Data collection practices, verification, and use in statistics	☐	☐	☐
Privacy and protection(s) *(human, private health information, recombinant DNA, animal ethics considerations)*	☐	☐	☐
Research design consideration bias, objectivity in design, and analysis	☐	☐	☐
Reporting and publications	☐	☐	☐
General laboratory safety	☐	☐	☐
Peer review	☐	☐	☐

In the context of the experiences noted below, have you ever been assessed by your instructors or PI regarding your understanding or skills in the following topics?
Please select all that apply for both experiences.

	CURE(s)	Faculty-Mentored Research	Neither Experience
Collaboration *(including professional conduct and communication)*	☐	☐	☐
Ownership *(including project data)*	☐	☐	☐
Authorship *(including responsible communication, author order)*	☐	☐	☐
Research misconduct *(including falsification and/or fabrication of data, issues in record-keeping, or other protocol-specific concerns)*	☐	☐	☐
Data management *(including sharing, acquisition, preservation, and ownership)*	☐	☐	☐
Mentor/trainee responsibilities	☐	☐	☐

Data collection practices, verification, and use in statistics	☐	☐	☐
Privacy and protection(s) *(human, private health information, recombinant DNA, animal ethics considerations)*	☐	☐	☐
Research design consideration bias, objectivity in design, and analysis	☐	☐	☐
Reporting and publications	☐	☐	☐
General laboratory safety	☐	☐	☐
Peer review	☐	☐	☐

With respect to those experiences indicated below, when do you think it is best for responsible and ethical conduct of research (RECR) topics to be introduced?
Please select all that apply for both experiences.

	CURE(s)	Faculty-Mentored Research	Neither Experience
At the beginning of the experience.	☐	☐	☐
When it is relevant to the laboratory activity.	☐	☐	☐
At the end of the experience.	☐	☐	☐
Other: _____	☐	☐	☐

Please briefly describe your reasoning for the choices made in question 16 (above):

To what extent have you experienced the integration of responsible and ethical conduct of research (RECR) training in the experiences indicated below?
Please select all that apply for both experiences.

	CURE(s)	Faculty-Mentored Research	Neither Experience
A separate didactic portion associated with the lab course and/or faculty-mentored research experience	☐	☐	☐
A workshop, seminar, or class separate from the lab course and/or faculty-mentored research experience	☐	☐	☐
Practical, context-based instruction in the CURE and/or faculty-mentored research lab	☐	☐	☐

In the context of CURES and responsible and ethical conduct of research (RECR) instruction, to what extent have you participated in the following activities?

	Never	*Rarely*	*Sometimes*	*Often*	*Always*
Role-play or "choose your own adventure" exercises	☐	☐	☐	☐	☐
Case study or current event discussions	☐	☐	☐	☐	☐
Practical application (learning by doing)	☐	☐	☐	☐	☐
Lecture-based workshop or seminar	☐	☐	☐	☐	☐
Online training or game (simulation or other)	☐	☐	☐	☐	☐
Presentation or debate assignment	☐	☐	☐	☐	☐
Written assignment	☐	☐	☐	☐	☐
Other: _____	☐	☐	☐	☐	☐

If 'Other' was selected for question 19 (above), please briefly describe this activity.

We are interested in learning more about your perceptions and experiences about RECR in a faculty-mentored laboratory and/or CURE context and would therefore like to invite you to participate in a brief (~30-min.), semi-structured interview. If you are willing to participate in the interview, please enter your e-mail address below.

Upon completion of this survey, you are eligible to enter a drawing for one (1) of four (4) $25 gift cards. Entry into the drawing is entirely optional. If you would like to enter this drawing, please enter your e-mail address below:

Additionally, we are interested in developing RECR activities to be integrated within CUREs. If you are interested and would like to be contacted by e-mail about future research opportunities, please indicate your interest by checking the appropriate box:

☐ **Yes, I am interested in being re-contacted by e-mail**

☐ **No, I am not interested.**

Appendix B: Scalability and Sustainability of RECR Survey and Interview

University of Texas at El Paso (UTEP) Institutional Review Board
Informed Consent Form for Research Involving Human Subjects

Protocol Title: Factors that Impact the Scalability and Sustainability of Responsible and Ethical Conduct of Research (RECR) Education within Course-based Undergraduate Research Experiences (CUREs).
Principal Investigator: Jeffrey T. Olimpo, Ph.D. (jtolimpo@utep.edu) and Bernice Caad, B.Sc. (bcaad@utep.edu)
UTEP: Biological Sciences, B226A Biology Bldg.
Funding: Self-Funded

In this consent form, "you" always means the study subject. If you are a legally authorized representative, please remember that "you" refers to the study subject.

Introduction

You are being asked to take part voluntarily in the research project described below. You are encouraged to take your time in making your decision. It is important that you read the information that describes the study. Please ask the study researcher or the study staff to explain any words or information that you do not clearly understand.

Why is this study being done?

You have been asked to take part in a research study focused on identifying factors that impact the scalability and sustainability of responsible and ethical conduct of research (RECR) education within course-based undergraduate research experiences (CUREs). Furthermore, this research seeks to provide additional insights into the effective incorporation of RECR education within CURE curricula.

Approximately 20 stakeholders (e.g., faculty; staff; graduate teaching assistants; administrators; community partners) will be asked to enroll in this study at UTEP.

You are being asked to be in this study because you are:

- At least 18 years of age; and
- Currently involved in the development, implementation, and/or evaluation of CURE curriculum.

If you decide to enroll in this study, you will be asked to provide survey data and participate in one semi-structured interview, totaling approximately 40 - 60 minutes. Please note that all research activities will be conducted remotely (i.e., you will not be asked, at any point throughout the duration of the research study, to engage in face-to-face interactions or activities).

What is involved in the study?

If you agree to take part in this study, the research team will:

- Address any questions or concerns you might have about this consent document and briefly provide a verbal description of the research study.
- Ask that you please complete an informational survey, anticipated to last no longer than ~10-15 minutes, designed to address the study purpose, as described above. Specifically, this survey will be administered electronically through UTEP's QuestionPro platform prior to your participation in the semi-structured interview process. Demographic data will be obtained as part of this survey as will information regarding your role within your institution/organization, educational background, etc.
- Invite you to participate in one semi-structured interview, to be conducted after you complete the informational survey referenced above. This interview will be scheduled at your convenience and is anticipated to last no longer than ~30 - 45 minutes. All interviews will occur via Zoom and will be audio and video-recorded for the purposes of transcription and data analysis. These interviews are designed to provide direct insight into those factors that are perceived to have an impact on the scalability and sustainability of RECR education within CUREs.
- Ask, at the end of the interview, if you are interested in being re-contacted by e-mail regarding future RECR research opportunities.

What are the risks and discomforts of the study?

There is minimal risk associated with participation in this study. You may become self-conscious while completing the survey or while being audio or videotaped. You may request that the research team cease collection of audio and/or video-data at any point throughout the duration of the study or stop at any time with no repercussions or penalty. As the study involves the use of audio/video-recorded interviews, if you consent to participate in this portion of the study, there is the possibility that you may experience a loss of privacy and confidentiality due to the nature of the research environment. To minimize these risks, the audio and/or videotaped data will only be shown in settings for professional educators and scientists (e.g., professional meetings or conferences; laboratory research meetings), and, in all cases, you will be referred to by a pseudonym.

Are there benefits to taking part in this study?

There are no guaranteed benefits to you. However, this research is intended to provide valuable insights into the factors that may influence the scalability and sustainability of responsible and ethical conduct of research (RECR) education within CUREs. Ideally, this research will also result in increased student exposure to ethical tenets within authentic research environments.

What are my costs, and will I be paid to participate in this study?

There are no direct costs. If you complete the above-mentioned survey and interview in its entirety, you will be given a $20 electronic gift card as a "thank you" for your time. Your gift card will be sent to the e-mail address that you provided at the end of the interview.

What other options are there?

You have the option not to take part in this study. There will be no penalties involved if you choose not to take part in this study. Choosing to withdraw or not participate will not affect your grades, employment or university standing.

What if I want to withdraw, or am asked to withdraw from this study?

Taking part in this study is voluntary. You have the right to choose not to take part in this study. If you do not take part in the study, there will be no penalty or loss of benefit. If you choose to take part, you have the right to skip any questions or stop at any time. However, we encourage you to talk to a member of the research group so that they know why you are leaving the study. If there are any new findings during the study that may affect whether you want to continue to take part, you will be told about them. The researcher may decide to stop your participation without your permission if he or she thinks that being in the study may cause you harm.

Please note that if you initially elect to participate in the study but later choose to withdraw from the study or are removed from the study, any data that you provided will not be included in any part of the analysis or dissemination phases of the project. In the event that you would like to withdraw from the study, please contact the project PI, Dr. Jeffrey Olimpo, at jtolimpo@utep.edu or Bernice Caad at bcaad@utep.edu. Please note, however, that once your data has been de-identified and can no longer be linked to you, the research team will not be able to remove your data from the study.

Relatedly, please note that if you do not consent to be audio-/video-recorded as part of the study, you will no longer be eligible to participate in the study.

Who do I call if I have questions or problems?

You may ask any questions you have now. If you have questions later, you may contact Dr. Jeffrey Olimpo at phone: (915) 747-6923; e-mail: jtolimpo@utep.edu or Bernice Caad at e-mail: bcaad@utep.edu .

If you have questions or concerns about your participation as a research subject, please contact the UTEP Institutional Review Board (IRB) at (915) 747-8841 or irb.orsp@utep.edu.

What about confidentiality?

To maintain the confidentiality of your records, any audio and/or video recordings collected with your consent will be stored in a locked filing cabinet in the office of PI, Dr. Jeffrey Olimpo (B226A Biology Bldg.); electronic or paper artifacts (such as survey data) will be stored as password-protected files on Dr. Olimpo's password-protected workstation (housed in B226A, Biology Bldg.) **and/or** as encrypted, password-protected files on the Microsoft OneDrive platform sanctioned by the university in accordance with all mandatory policies and procedures. Survey data, recordings, and identifiers will be accessible only by trained members of the research team and only for the purposes of coding, qualitative data analysis (e.g., identifying themes in participant responses across the dataset), and quality control (e.g., bot verification and consolidation of duplicate responses). Upon completion of transcription, data analysis, and reporting, your audio- and video recordings will be immediately destroyed. Please note that if a quote from you is presented (e.g., at a research conference or publication), you will be referred to by a pseudonym to maintain your confidentiality. All identifiable data will be retained for a period of 5 years, before being de-identified and destroyed. De-identified data, that cannot and will not be linked back to you, will be retained indefinitely.

Every effort will be made to keep your information confidential. Your personal information may be disclosed if required by law. Please also note that the following organizations may request to inspect and/or copy your research records for quality assurance and data analysis:

- Office of Human Research Protections
- UTEP Institutional Review Board

Because of the need to release information to these parties, absolute confidentiality cannot be guaranteed. Relatedly, you may be contacted (via e-mail) by PI Olimpo or Co-PI Bernice Caad if they are required to do so by law or in the event that further clarification is needed from you.

Authorization Statement

I have read each page of this paper about the study (or it was read to me). I know that being in this study is voluntary and I choose to be in this study. I know I can stop being in this study without penalty. I know that I can print off a copy of this consent form to keep or request a copy from the research team at a later date.

_____
Participant's Name (printed)

_____ _____
Participant's Signature Date

_____ _____
Participant's Student/Employee ID # (Quality Control) Date

_____ _____

Signature of Person Obtaining Consent Date

Do you provide consent to be video- and/or audiotaped during that interview? (Please check the appropriate line below)

☐ Yes, I provide consent to be video- and/or audiotaped during my participation in the interview.

☐ No, I do not provide consent to be video- and/or audiotaped during my participation in the interview.

Sample Survey Questions	
	What is your name, affiliation, and e-mail address? **Note:** Participants will be asked to provide their name, affiliation, and e-mail address prior to the start of the interview during the pre-interview questionnaire. This information will not be included in our analyses and will only be retained to confirm the identity of the participant for record-keeping purposes and to match survey responses to interview data.
	What is your position at [institution/organization]? How long have you held that position? What role do you play in the development of CURE curricula?
	If applicable, how many total semesters of teaching experience do you have (including teaching assistant and adjunct appointments)? Can you describe the courses that you taught?
	If applicable, how many total semesters of laboratory teaching experience do you have (including teaching assistant and adjunct appointments)? Can you describe the laboratory courses that you have taught?
	How many semesters have you acted as a mentor for undergraduate/graduate students in a research setting at any institution? (outside of a classroom/teaching setting)
	Did you take advantage of responsible and ethical conduct of research (RECR) training opportunities in your current and past role(s)? If so, please briefly describe those opportunities.
	Have you ever received any formal training on acting as a mentor in a research setting? If so, please briefly describe the training that you received.

	Have you ever received any formal pedagogical training (i.e., education on effective teaching practices in the context of RECR)? If so, please briefly describe the training that you received.
	With which gender do you most identify? **Note:** Choices include: Man, Woman, Non-binary or non-gender confirming, and I prefer not to respond.
	What is your race/ethnicity? (Please select all that apply) **Note:** Choices include: Black or African American, White, Hispanic or Latinx, Asian, American Indian or Alaska Native, Native Hawaii or Pacific Island, I prefer to self-describe.
	Are you interested in being re-contacted for future research related to responsible and ethical conduct of research (RECR)? **Note:** Choices include: Yes and No. Participants who indicate yes will be asked to provide their e-mail address.

Sample Interview Questions	
Attributes of the innovation/intervention	
	Do you feel that it is valuable to provide responsible and ethical conduct of research (RECR) training within undergraduate laboratory education? Why, or why not? Do you feel that RECR education is more valuable in a CURE laboratory than in a traditional, faculty-mentored laboratory setting? Why or why not?
Credibility of model (evidence base for innovation)	
	Do you feel there is evidence to support the need for targeted RECR education within CURE curriculum, in particular? Why, or why not?
Relevance to concern of potential adopters	
	How might the integration of RECR education within a CURE benefit students during their undergraduate degrees? What about after graduation?
Relative advantage over existing practice	
	To your knowledge, what type of RECR programs or opportunities currently exist within your department or college, if any? What is your opinion of their effectiveness? Do you think targeted integration of RECR within CUREs would be more advantageous for students than in existing faculty-mentored experiences? Why, or why not?
Simplicity or ease of adoption	
	If CURE programming were expanded to other departments (liberal arts, etc.) do you think RECR would be applicable or of interest to other CUREs within those departments? Why, or why not?
Model testable and adaptable	
	If RECR education within CUREs were expanded to support other departments, how might this education be adapted to suit their needs?
Aligned and harmonized with existing RECR education programs	
	Would integration of RECR education within CUREs complement existing RECR education within the/your [graduate school; department; etc.]?
Networking, collaboration and partnership (to foster buy-in)	

	How might faculty encourage and support participation in RECR education within your department? Division? **Note:** This question will be rephrased to fit the role of the respondent. For instance, an adaptation of this question might read: "how might members of the graduate school encourage and support the integration of RECR education on campus?"
Capacity to support scale-up (skills, size, resources and experience)	
	What do you perceive to be the challenges/obstacles associated with the scalability and sustainability of RECR education within CUREs and/or faculty-mentored research?
Capacities for data collection and reporting systems	
	Do you feel that the outcomes associated with undergraduate participation in RECR education would be of interest to the greater STEM community? Why, or why not?
Timing or window of opportunity	
	At what point, (beginning, middle, or end) of the semester should RECR be presented within a CURE? Is this the right time to try to introduce and sustain RECR education within CUREs and/or faculty-mentored research? Why, or why not?

Vita

Bernice J. McGrath-Caad was raised in Dartmouth, Nova Scotia, and Calgary, Alberta, where she graduated high school in 2008. Bernice spent her early adult life in Canada before later moving to El Paso, Texas, to join her partner, who was an active duty servicemember. Bernice earned her Bachelor of Science degree in Cellular and Molecular Biochemistry from The University of Texas at El Paso in 2018. Bernice currently works as an IRB Analyst at The University of Texas at Austin and assists the UT research community with navigating regulatory processes and ethics related to human research. Prior to this position, she worked as an IRB Administrator at the University of Texas at El Paso. Bernice aspires to continue in academia and hopes to one day achieve a leadership position in the human research field to mentor the next generation of regulatory specialists.

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