

Changing Attitudes Towards Research Through a Course-based Undergraduate Research Experience

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Abstract: Studies show undergraduate students typically view the idea of research negatively, with students reporting feelings of anxiety, difficulty, detachment, and reduced perceptions of relevancy to their own life. Course-based undergraduate experiences (CUREs), where students have an opportunity to engage in authentic research experiences, can reach large number of students in a convenient fashion, thus, are well-positioned to shift student perceptions of research. The purpose of this study is to explore changes in attitudes towards research in a large sample of undergraduate students' after completing one semester of a CURE, either in-person or online due to COVID-19. This study used a within-subjects pre-posttest design. Data collection took place over eight semesters from fall 2019 through spring 2022 at a large metropolitan public university in the southeast region of the United States. Students enrolled in the CURE were asked to complete the Attitude Towards Research scale at the beginning and end of the semester covering the following factors: usefulness of research (F1), anxiety (F2), affect indicating positive feelings about research (F3), life relevancy of research to the students' daily lives (F4), and difficulty of research (F5). Wilcoxon signed rank tests for paired data were conducted and Mann-Whitney U tests assessed whether there were any differences between students who completed the course face-to-face versus online. Across all eight semesters, 1,003 students (74% female, 91% Seniors) provided valid pre-posttest data. Statistically significant improvements were observed across all semesters (online and face-to-face) for research anxiety, positive attitude towards research, research relevance to own life, and research difficulty from the ATR scale ($p < 0.05$). For usefulness of research for profession (F1), statistically significant differences were observed in four out of the eight semesters ($p < 0.05$). Changes in students' attitudes towards research did not differ between course modality (face-to-face versus online) except for F1. The mean change in F1 was different between students taking a face-to-face (mean: 0.22, \pm SD 1.02) versus online version (mean: 0.07, \pm SD 0.72) of the course ($z = 2.35$, $p = 0.02$). Findings from this study demonstrate the potential of a CURE at reducing anxiety, lowering perceived difficulty, enhancing overall impressions, and students' overall attitudes toward research and research-based education. Continued consideration and evaluation of how and what is delivered in CUREs to students is required to advance the pedagogy of research methods.

Keywords: undergraduate education, research methods, student anxiety; student perceptions.

Understanding key principles of research methodology and developing information literacy skills are essential to, most, if not all, undergraduate students preparing for social science and human service careers, which often rely on a fundamental knowledge of research in order to stay up to date with best practices (Earley, 2014; Rodriguez & Toews, 2005). Further, gaining mastery of research methods

provides an opportunity to build technical and transferable skills that are an asset for post-baccalaureate careers, either graduate schools or in industry (Auchincloss et al., 2014).

There are a variety of ways undergraduate students can gain research experience, such as participating in research-focused internships, assisting with research under the supervision of a faculty member, taking part in training or certificate programs, or enrolling in a research methodology course. Research methods courses are often required as part of most social and health science degree programs (Wishkoski et al., 2022).

Research methodology courses, where students can engage in authentic research experiences (Bangera & Brownell, 2014), have more recently been defined as Course-based Undergraduate Research Experiences (CUREs) (Auchincloss et al., 2014). CUREs offer several advantages over other research opportunities and have great potential to increase access to, understanding of, and involvement in the research process. CUREs have 1) the ability to involve a larger number of students in research-related activities, 2) lower barriers to entry (e.g., enroll in course vs. seek-out and apply process), 3) the potential to impact students' perceptions of research earlier in their academic career, and 4) lower extra-curricular time commitments (e.g., students participate during a designated time as part of their semester class schedule)(Auchincloss et al., 2014; Rowland et al., 2012; Bangera & Brownell, 2014).

Although engaging undergraduate students in research-related courses and experiences is of paramount importance for intellectual and professional growth, studies show across disciplines that undergraduate students typically view research and research-related methodology courses negatively, with students reporting feelings of anxiety, difficulty, detachment, and reduced perceptions of relevancy to their own life (Braguglia & Jackson, 2012; Earley, 2014; Wishkoski et al., 2022). In the immediate, negative perceptions or attitudes toward research can inhibit student knowledge and understanding of course content (Adams & Holcomb, 1986; Earley, 2014; Elmore & Lewis, 1991; Slocum-Schaffer & Bohrer, 2021). However, studies in the health-care field show that post-graduate students with negative attitudes toward research deprioritize the importance of evidence based-practice and do not seek out new knowledge or use current evidence to support patient care (Ross & Burrell, 2019).

Providing quality research methods education through high-impact CUREs is of paramount importance, and CUREs can offer students rich experiences that focus more on collaboration, critical thinking, and communication skills – all vital elements of research. Further, CUREs are well-positioned to impact student perceptions of research given the large amount of students they can reach. . CUREs offer a unique opportunity for the learner by shifting the emphasis from the '*what*' (i.e., the outcome) to the '*how*' (i.e., the process), thus, students can gain confidence and a richer understanding of research and the various facets that make up the research process.

Only a handful of studies have explored changes in students' attitudes toward research when enrolled in CUREs or research-related courses, necessitating longitudinal research to be conducted in this field (Earley, 2014; Ross & Burrell, 2019; Valdez & Liu, 2020).

The purpose of this study is to explore changes in students' attitudes towards research after completing one semester of a 3-credit undergraduate research-intensive applied health research methodology course (i.e., CURE). Due to the Coronavirus Disease 2019 (COVID-19) taking place during certain data collection semesters, a secondary exploratory aim was to determine if differences existed in attitudes toward research among students who participated in online versus face-to-face modalities of the CURE.

Methods

Study Design, Sample, and Setting

This study used a within-subjects pre-posttest design to examine changes in undergraduate students' attitudes towards research after enrolling and participating in a semester-long CURE. Data collection took place over eight semesters from fall 2019 through spring 2022 at a large metropolitan public university in the southeast region of the United States. Eligible participants were minoring or majoring in health sciences and were junior or senior students currently enrolled in a research methods course during these semesters. Typically, these students are interested in pursuing the medical profession (e.g., medical school, physician assistant program, doctorate in physical therapy) post-graduation. All data collection procedures were approved by the lead authors institutional review board (IRB). Due to the non-sensitive and anonymous nature of the information being collected, the current study received an exempt status from the IRB.

Course-based Undergraduate Research Experience (CURE)

The 3-credit undergraduate research methodology course has a 'research-intensive' (RI) designation awarded by the Division of Student Learning and Academic Success in the Office of Undergraduate Research. The RI designation is awarded following a review of the core course content and key deliverables. This designation stipulates that the course provides curriculum-based active engagement in a line of inquiry that is guided by a content expert, adheres to aspects of the academic research or scholarship process, and includes a research-related deliverable. Broadly, the RI designation gives faculty the opportunity to enrich the students' understanding through sharing insights from their own knowledge and experiences, whilst simultaneously, students learn critical thinking skills, bolster formal academic communication skills through both written and oral formats, and gain a deeper understanding about the research process itself within their discipline. The CURE content was delivered over a 16-week semester (12 weeks for summer semesters) and included class lectures and discussions surrounding topics such as critical thinking, study designs, sampling, measurement, research ethics, and data analysis and dissemination. In addition, key research-related components and deliverables (see **Table 1**) are required throughout the semester that are individual or group-based.

Table 1. Main components/deliverables of the Course-based Undergraduate Research Experience

Course Component	Description: <i>Students are required to...</i>	Objectives
The Collaborative Institutional Training Initiative (CITI Program)	Register an account and complete the following three courses/modules: 1. Human Research 2. Social and Behavioral Responsible Conduct of Research 3. Conflict of Interest	<ul style="list-style-type: none"> • To educate the students on research ethics and compliance • To provide the students with a research credential to assist with participation in human-subjects research
Peer-reviewed Journal Article Review	Complete three article reviews of an assigned peer-reviewed manuscript. The review consists of answering 10 questions about the article and completing a short three-sentence summary of the study.	<ul style="list-style-type: none"> • To provide opportunities for students to practice their reading and critical skills when reviewing the peer-reviewed scientific literature • To provide opportunities for students to practice their scientific writing skills
Research Grant Proposal	Form investigative teams to formulate and design a 6-page research proposal on a well-defined research question. Students must address significance of topic, state their aims and hypotheses, identify the appropriate study design, protocols, measures, and analysis, and consider study limitations and future directions.	<ul style="list-style-type: none"> • To provide opportunities for students to engage in the 'research process' (i.e., identifying an area of significance, developing a research question, and designing a methodologically sound study to answer the question). • To provide opportunities for students to work in investigative teams
Research Grant Proposal Poster and Presentation	Produce a conference-style research poster based on their research proposal. Groups are invited to present their poster at a bi-annual undergraduate research symposium. Posters are judged by a panel of faculty/staff from a variety of health-related disciplines.	<ul style="list-style-type: none"> • To provide opportunities for students to disseminate their research proposal using different formats, encouraging the communication and illustration of their ideas • To provide opportunities for students to present their research proposal in a professional/scientific setting

Protocol

Students enrolled in the research-intensive course were asked to complete the Attitude Towards Research (ATR) scale (Papanastasiou, 2005) during the first week of the semester (pre), and again during the last week of the semester (post). Administration of the ATR scale was completed through Canvas, a web-based learning management system commonly used by educational institutions and educators for managing course content, communicating with students, and assigning course-related tasks and assignments. Students received 5 points for completing the scale at both timepoints (10 total), contributing approximately +2.4% to their final grade. Students completed the post assessment prior to final grades being released for the semester.

The course was taught by the same faculty member for all eight semesters; fall 2019, spring, summer, and fall 2020, spring, summer, and fall 2021, and spring 2022. The faculty member was an assistant professor (PhD) with a research focus on childhood obesity. Face-to-face instruction of the course took place during fall 2019, spring 2020, fall 2021, and spring 2022 semesters. The course was adapted to be delivered online via Canvas due to the Coronavirus disease 2019 (COVID-19) for summer and fall 2020, and spring and summer 2021 semesters. Course content and deliverables did not change due to the transition online. Class lectures, discussion, research group meetings, and the research symposium were all delivered virtually via the Zoom[®] platform (Zoom Video Communications, Inc.).

Measures

Student attitudes toward research were assessed using the validated ATR scale (Papanastasiou, 2005). The ATR scale assesses multiple aspects of undergraduate students' attitudes toward research, and has been used previously in studies investigating attitudes toward research of undergraduate students in the US (Wishkoski et al., 2022). From a factor analysis, the scale produces results across five factors; usefulness of research (F1), anxiety (F2), affect indicating positive feelings about research (F3), life relevancy of research to the students' daily lives (F4), and difficulty of research (F5). The ATR scale consists of 32-items on a 7-point Likert scale. A score of 1 represents the option "strongly disagree", with the score 7 on the scale representing "strongly agree".

Data Analysis

At the end of each semester, all data were downloaded from Canvas, deidentified, and cleaned to only include students who had fully completed a pre- and post-test ATR scale. Each semester's dataset was combined to generate a single dataset for analyses. Scale items related to F2 (research anxiety) and F5 (research difficulty) were reverse coded, so a higher value indicated less anxiety or difficulty. Each item on the scale was summed and averaged to produce a pre- and post-test score for each individual factor (F1 to F5) (Papanastasiou, 2005). A Shapiro-Wilk test of normality was conducted due to the data being ordinal in nature. These data did not follow a normal distribution, thus, a Wilcoxon signed rank test for paired data (non-parametric) was conducted to assess changes in students' attitudes towards research across the five factors. A Mann-Whitney U test assessed whether there were any differences between students who completed the course face-to-face versus online. Statistical significance was set at $p < 0.05$ and all analyses were performed using Stata (v.16.1, College Station, TX).

Results

During the eight academic semesters, 1,111 students enrolled in the research methodology course (91.4% seniors, 73.5% female), and approximately 90% of students (n=1,003) provided valid pre- and post-test data (**Table 2**). Results from the main analyses shows statistically significant improvements across all semesters (online and face-to-face) for research anxiety, positive attitude towards research, research relevance to own life, and research difficulty from the ATR scale ($p < 0.05$). For usefulness of research for profession (F1), statistically significant differences were observed in four out of the eight semesters ($p < 0.05$). Three out of the four of these semesters were from courses taught face-to-face. **Table 3** provides the pre- and post-test values, z test statistics, and p-values for all semesters across factors. Results from our Mann-Whitney U test revealed that changes in students' attitudes towards research did not differ between course modality (face-to-face versus online) except for F1. The mean change in F1 was different between students taking a face-to-face (mean: 0.22, \pm SD 1.02) versus online version (mean: 0.07, \pm SD 0.72) of the course ($z = 2.35$, $p = 0.02$).

Table 2. Course enrollment and Attitude Toward Research (ATR) scale completion by semester

Semester	Course Modality	Course Enrollment*	Percent Females**	Percent Seniors**	Course Completed & Post ATR Scale	Pre ATR Percent Completion
Fall 2019	Face-to-Face	154	70.8%	85.1%	127	82.5%
Spring 2020	Face-to-Face	164	67.1%	86.0%	149	90.9%
Summer 2020	Online	81	75.3%	91.4%	69	85.2%
Fall 2020	Online	170	78.8%	96.5%	149	87.6%
Spring 2021	Online	145	71.7%	89.7%	136	93.8%
Summer 2021	Online	82	74.4%	98.8%	73	89.0%
Fall 2021	Face-to-Face	165	78.2%	92.1%	155	93.9%
Spring 2022	Face-to-Face	150	71.3%	92.0%	145	96.7%
Total		1111	73.5%	91.4%	1003	90.3%

*Two sections of the course were offered during fall and spring semesters taught by the same faculty member

**Information gathered from course enrollment roster post hoc

Table 3. Undergraduate students (N=1,003) attitudes towards research before and after participating in the CURE

Factor of Attitude Toward Research Scale	Timepoint	SEMESTER (Online = Shaded Grey)															
		Fall 2019 (n=127)		Spring 2020 (n=149)		Summer 2020 (n=69)		Fall 2020 (n=149)		Spring 2021 (n=136)		Summer 2021 (n=73)		Fall 2021 (n=145)		Spring 2022 (n=155)	
		M	SD ±	M	SD ±	M	SD ±	M	SD ±	M	SD ±	M	SD ±	M	SD ±	M	SD ±
F1: Usefulness of Research for Profession	Pre	5.75	0.85	5.65	0.95	5.67	0.92	5.64	0.98	5.76	0.87	5.85	0.88	5.66	0.93	5.75	0.94
	Post	5.75	1.04	6.08	0.88	5.78	1.03	5.75	0.97	5.82	0.97	5.85	0.97	5.84	0.94	5.99	0.89
	z test statistic (p-value)*	-0.247, (p=0.806)		-3.646, (p<0.001)		-1.058, (p=0.293)		-2.027, (p=0.043)		-1.515, (p=0.130)		-0.162, (p=0.873)		-2.379, (p=0.017)		-3.818, (p<0.001)	
F2: Research Anxiety ^a	Pre	3.36	1.10	3.38	1.12	3.33	1.05	3.33	1.15	3.46	1.15	3.71	1.21	3.52	1.09	3.34	1.09
	Post	4.05	1.12	4.46	1.14	4.31	1.18	4.17	1.11	4.28	1.15	4.45	0.98	4.35	1.07	4.14	1.01

	z test statistic (p-value)*	-6.554, (p<0.001)	-6.841, (p<0.001)	-5.491, (p<0.001)	-8.060, (p<0.001)	-7.354, (p<0.001)	-4.836, (p<0.001)	-7.738, (p<0.001)	-7.702, (p<0.001)
F3: Positive Attitude Toward Research	Pre	4.67 1.14	4.62 1.20	4.72 1.14	4.67 1.09	4.67 1.06	4.78 1.08	4.65 1.04	4.65 1.06
	Post	4.90 1.28	5.22 1.14	5.09 1.25	4.87 1.13	4.97 1.09	5.14 1.15	5.06 1.13	4.98 1.17
	z test statistic (p-value)*	-2.966, (p=0.003)	-4.027, (p<0.001)	-3.105, (p=0.002)	-3.044, (p=0.002)	-3.477, (p<0.001)	-3.113, (p=0.002)	-5.264, (p<0.001)	-4.039, (p<0.001)
F4: Relevance of Research to Own Life	Pre	5.02 1.10	4.94 1.16	4.76 1.22	4.98 1.12	4.88 1.09	4.82 1.10	4.89 1.05	4.95 1.15
	Post	5.23 1.09	5.40 1.23	5.22 1.19	5.19 1.15	5.26 1.03	5.22 1.09	5.36 1.05	5.33 1.09
	z test statistic (p-value)*	-2.357, (p=0.018)	-3.326, (p<0.001)	-3.802, (p<0.001)	-2.938, (p=0.003)	-4.662, (p<0.001)	-3.253, (p<0.001)	-5.078, (p<0.001)	-4.338, (p<0.001)
F5: Difficulty of Research^a	Pre	4.52 0.94	4.52 1.04	4.32 1.12	4.55 1.20	4.49 1.12	4.75 1.07	4.56 0.99	4.44 1.08
	Post	5.09 1.09	5.12 1.15	5.10 1.13	4.93 1.05	4.80 1.07	5.15 1.01	5.05 1.00	4.91 1.04
	z test statistic (p-value)*	-5.738, (p<0.001)	-4.121, (p<0.001)	-4.776, (p<0.001)	-4.149, (p<0.001)	-3.231, (p=0.001)	-2.627, (p=0.008)	-5.596, (p<0.001)	-4.793, (p<0.001)

*Wilcoxon signed-rank test for paired comparisons; bolded values indicate statistically significant differences (p<0.05)

^a Items reverse coded so a higher value indicates less anxiety or difficulty

M=Mean, SD=Standard Deviation; Grey shaded columns represent online course delivery due to Coronavirus disease 2019 (COVID-19)

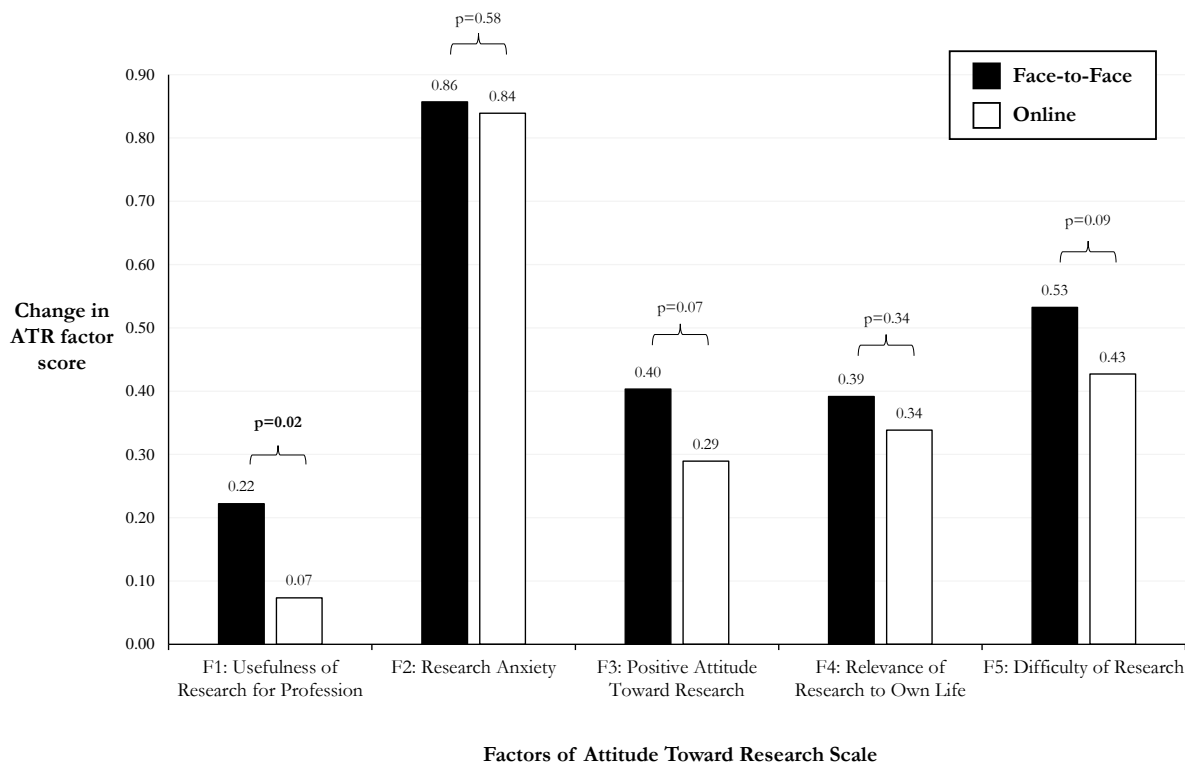


Figure 1. Comparison of factors of undergraduate students’ attitudes towards research scale by course modality (face-to-face versus online). N.b., Mann-Whitney U test to compare between-subjects differences; bolded values indicate statistically significant difference ($p < 0.05$)

Discussion

The aim this study was to explore changes in students’ attitudes towards research after completing one semester of a 3-credit CURE. A secondary exploratory aim examined differences existed in attitudes toward research among students who participated in online versus face-to-face modalities of the course. Overall, statistically significant positive improvements were observed across all eight semesters for each of the factors examined by the ATR scale, with some exception in the area of ‘usefulness of research for own profession’ by semester and modality. These data demonstrate one example of the potential of CUREs for reducing undergraduate students’ negative perceptions of research often associated with research and research-based education. Continued consideration and evaluation of how and what is delivered to students is required to advance the pedagogy of research methods.

Across eight different cohorts of undergraduate students enrolled in either the face-to-face or online research-intensive course, improvements were observed in research anxiety, positive attitude towards research, research relevance to own life, and research difficulty. Notably, the largest changes observed in students’ attitudes toward research, regardless of course modality, were reductions in ‘research anxiety’ (reduced). This is a particularly promising finding as, broadly, a reduction in anxiety is beneficial for emotional, academic, and health outcomes of students (Yusufov et al., 2019), however, a reduction in anxiety with regards to ‘research’ can maximize student success in the classroom and increase likelihood of retention in science (Cooper et al., 2018). Previous research evaluating undergraduate students’ perceptions of research enrolled in CUREs (Carson et al., 2018; Wishkoski et

al., 2022) has reported similar findings, albeit in smaller sample sizes. Wishkoski et al. conducted a mixed-methods longitudinal design to assess changes in undergraduate students' (n=78) attitudes, anxiety, perceptions of relevance, and disinterest in research after completion of a social science research methods course during fall and spring semesters at a mid-size research institution in the western United States (Wishkoski et al., 2022). The authors employed the ATR scale (Papanastasiou, 2005) pre- and post-completion of the course and reported positive increases across the students enrolled in the face-to-face and online modalities of the course. Similar to the results herein, the smallest or null differences observed in their study was for the factor '*usefulness of research for own profession*' (Wishkoski et al., 2022). In the present study, statistically significant differences in pre- versus post-values were detected in four of the eight semesters in both online and face-to-face modalities for this factor, leaving room for improvement in this area. A possible explanation for these findings may be due to the fact that the course was taught by the same faculty member, who has a very focused research topic and is encouraged to teach the class through their own research experiences. The examples and context used to deliver some of the course content may not resonate with students who are pursuing a different professional pathway, and, therefore, students may not see the utility in research for their own career aspirations. This is an important point to consider when delivering CUREs to large classes with diverse student career aspirations, a common circumstance in most social and health science degree programs. Nonetheless, these data provide encouraging information of the positive impact CUREs can have in changing the attitudes of undergraduate students. Given the numerous advantages of CUREs such as the ability to serve a large number of students and the diminished barriers to access the course (Auchincloss et al., 2014; Rowland et al., 2012; Bangera & Brownell, 2014), the implementation of CUREs offers a feasible and effective way to improve undergraduate students' perceptions of research whilst developing their knowledge and understanding of research methodology.

As noted previously, across the other factors, statistically significant differences were observed with students reporting lower anxiety and perceptions of difficulty, increased positive attitudes towards the topic, and an improved understanding of the importance of research for their own life. An encouraging finding is that these patterns held true when the course was delivered online due to the COVID-19 pandemic. Differences were observed in the change scores between students who took the course online versus face-to-face were observed, with students who completed the course online showing smaller positive changes in their attitudes towards research, although only one of these differences reached statistical significance ('*usefulness of research for own profession*'). It is worth mentioning that there were no differences in baseline (pre-semester) values between those students who participated in the course face-to-face versus online, and the main course components/deliverables did not differ. Students have reported the shift to online learning due to the COVID-19 pandemic as having a negative effect on their overall learning experience and motivation to learn (Serhan & Science, 2020). Other studies have found that students prefer certain components of courses – such as discussions and peer-to-peer interactions – to be more engaging and beneficial for them when conducted face-to-face (Kemp & Grieve, 2014; Paechter et al., 2010). The current study's' CURE dedicates several classes throughout the semester to discussion, and perhaps the transitioning of these discussions to an online format reduced the learning experience for students taking the class online. The differences observed herein are in contrast to another study reporting data on students' perceptions of research showing higher changes among online students versus face-to-face (Wishkoski et al., 2022), however the study was limited by sample size (N=78) and examining only two semesters of course delivery. The COVID-19 pandemic will likely have a lasting effect on how courses are designed and delivered. Educational institutions invested significant resources to connect students with course content and to manage the administration of online learning (Lockee, 2021). With this infrastructure in place, it is likely that more online course options may be utilized moving forward.

There are advantages to online versus face-to-face learning, such as self-learning, low costs, convenience, and flexibility (Almahasees et al., 2021), however, consideration of appropriate course modality and interaction requirements (e.g., synchronous versus asynchronous) to meet course objectives is required to ensure the educational needs of the students are being met

A review of the literature spanning four decades on the teaching and learning of research methods reported a variety of techniques have been adopted to improve attitudes and interest in the subject, from active and problem-based learning to cooperative or service learning (Earley, 2014). From the 38 articles identified, a common goal expressed by education practitioners was ultimately to immerse students in research-related activities that emphasize ‘learning by doing’. The most common activity embodying this approach in CUREs is having students engage in the development of a research project and/or proposal either as an individual or as part of a group (Earley, 2014). Students enrolling in the CURE in the present study had several research-related activities. However, the main research-related activity was to form an investigative team (self-select) and design a research proposal centered on a well-defined human-subjects research question. Students must address significance of topic, clearly define aims and hypotheses, identify an appropriate study design (i.e., experimental, cross-sectional, case-control, longitudinal study), and suitable protocols, measures, and analysis to conduct the proposed research study (Table 1). Topics can range from the design of a study comparing the effectiveness of low-dose estrogen versus bisphosphonates for the prevention of osteoporosis in post-menopausal women to exploring the use of mental health resources on campus by immigrant students. Aspects of this activity are grounded in situated-learning theory, the embodiment of ‘learning by doing’, whereby learning is fostered through engagement in a “*community of practice*” with individuals forming a team to work toward a common goal guided by a set of common practices – in this case, research methodology theory (Lave & Wenger, 1991). Additional benefits of adopting this approach are manifested through increased interactions between faculty and students as they seek feedback on their research projects, and the development of peer-to-peer relationships which can help cultivate communication and leadership skills (Seymour et al., 2004). Collectively, implementing collaborative assignments and activities align with the mission of longstanding educational organizations – such as the Carnegie Foundation for the Advancement of Teaching – that call for a greater emphasis on high-impact practices that provide engaging learning experiences to foster the development of skills and knowledge critical for success in work, life, and citizenship (McNair & Albertine, 2012). Lastly, research has identified potential strategies for practitioners considering implementing CUREs that may enhance the research experience for undergraduate students. Fischer et al. proposed a layered taxonomy grounded in best practices across disciplines, exposure to a variety of research tasks, student achievement level, with milestones of increasing engagement throughout the course (Fischer et al., 2021), whereas others have suggested the implementation of sequential CUREs over multiple semesters that steadily build research engagement and experiences for the undergraduate student (Killon et al., 2021).

Strengths of this study include a large sample size and the examination of different modalities (face-to-face versus online) of the same research-intensive course by the same faculty member which helps control for instructor differences. Another strength of this study was the lack of selection bias. Students often have more autonomy over course selection and/or modality preferences (Stack & Learning, 2015), however, due to COVID-19, students in the present didn't have the option to choose one over the other. Further, previous research has noted there is a lack of reporting of course content and/or objectives of research methods course activities (Earley, 2014). The present study provides insights to key components of the CURE offered to the undergraduate students in this study and corresponding objectives related to the specific research assignment or activity. The description of the key course component in this study may aid future educational professionals with the design and

delivery of key research content that has the potential to improve undergraduate students' attitudes towards research.

There are limitations of the current study that must be noted. There are no demographic data tied to the ATR scale outcomes, thus making it difficult to explore the impact the course has on students' attitudes by subgroups such as sex, race/ethnicity, and research experience prior to enrolling in the course. Generalizability of findings may be limited due to the study sample representing students from a single discipline (Health Sciences), and although data from a single instructor can be viewed as a strength, future research should consider diverse samples of undergraduate students enrolling in CUREs led by faculty of different educational backgrounds, training, and expertise. Lastly, collecting detailed qualitative information on undergraduate students' experiences in CUREs may provide a deeper understanding on the value of CUREs at influencing students' perceptions of research.

In summary, findings from this study demonstrate the potential of a CURE at reducing anxiety, lowering perceived difficulty, enhancing overall impressions, and students' overall attitudes toward research and research-based education. In contrast to traditional research experiences (e.g., a select group of students engage in research activities under the supervision of a faculty member), CUREs offer a cost-effective, widely accessible, quality research experience for a large number of undergraduate students (Auchincloss et al., 2014). Further, evidence has shown that CUREs can reduce the equity gap by providing undergraduate students from underrepresented minority groups – individuals who are less-likely to engage in research experiences at the undergraduate level – with greater research exposure and experiences (Bhattacharyya & Chan, 2021; Bangera & Brownell, 2014). Collectively, to optimize student learning via CUREs, continued consideration and evaluation of how and what is delivered to students is required to advance the pedagogy of research methods. Specifically, educators and practitioners need to consider how the research experience for undergraduates can be scaled across the curriculum, adjusted to optimize student engagement, and designed to facilitate student preparation and desired learning outcomes (Fischer, 2021).

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