Hutson, B. L., & Buchanan, L. (2025). Transforming Undergraduate Research Experiences: A Five-Year Impact Study of a Quality Enhancement Plan at a Large Public University. *Intersection: A Journal at the Intersection of Assessment and Learning, 6*(3), 19-45.

Transforming Undergraduate Research Experiences: A Five-Year Impact Study of a Quality Enhancement Plan at a Large Public University

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"We have no conflicts of interest to disclose."

Intersection: A Journal at the Intersection of Assessment and Learning

Vol 6, Issue 3

Abstract: This study examines the implementation and five-year impact of a Quality Enhancement Plan (QEP) focused on transforming undergraduate research experiences at a large public university. The QEP aimed to broaden student access to research experiences through four initiatives: Integrated Curricula, Course-based Undergraduate Research Experiences (CUREs), Makerspace Integration, and Research Exposure Opportunities. Impact was assessed across three key domains: student learning outcomes, development of research skills, and interdisciplinary engagement. Assessment methods included pre- and post-course content knowledge tests, research skill surveys, project ownership surveys, and participation data. Results demonstrated significant gains in students' disciplinary content knowledge, research self-efficacy, and project ownership. Findings highlight the potential for embedded, course-based models to expand access to high-impact educational experiences and foster sustained research engagement for all students.

Keywords: *undergraduate research, high-impact practices, faculty learning communities, learning improvement, quality enhancement*

Introduction

Undergraduate research experiences have been widely acknowledged as a transformative and impactful educational practice, contributing significantly to student learning, engagement, and preparation for future careers or graduate studies (Kuh, 2008; Lopatto, 2007). However, traditional mentored research experiences often face limitations in terms of scalability and accessibility, potentially excluding many students from these valuable opportunities (Bangera & Brownell, 2014).

In response to these challenges, the University of North Carolina at Chapel Hill (UNC) implemented a comprehensive Quality Enhancement Plan (QEP) in 2017, titled "Creating Scientists: Learning by Connecting, Doing, and Making." This initiative aimed to provide transformative research experiences to a broader range of undergraduate students through innovative curricular and co-curricular approaches.

This study examines the impact of the five-year QEP on student learning outcomes, research skills, and engagement across disciplines. By analyzing the implementation and outcomes of this large-scale initiative, we aim to contribute to the ongoing dialogue about effective strategies for integrating research experiences into undergraduate education at research universities.

UNC's 2017 QEP had the goal of providing students with opportunities to learn through exploration, discovery, testing ideas, iteration, and collaboration. These are hallmarks of transformative research experiences and are central to UNC's mission as a leading, global public research institution. The approaches to undergraduate research promoted through the QEP offered an opportunity to test their potential for scalability, accessibility, and inclusivity.

Our QEP had two overarching student learning outcomes:

1) students will demonstrate improved communication and collaboration skills as members of scientific inquiry teams; and

2) students will be able to describe what it means to engage in research and be members of a community of researchers.

To achieve our learning outcomes while engaging a wide array of campus stakeholders, four initiatives comprised the QEP:

1) *Course-based Undergraduate Research Experiences (CUREs)* immersed students in research by engaging select classes in hypothesis-driven investigations. These courses featured semester-long research projects, enabling students to embrace failure as part of the learning process, take ownership of their work, collaborate with peers, and share their findings beyond the classroom. Before the QEP, undergraduate research at UNC was largely limited to independent experiences available to a small group of upper-level students. The QEP expanded access by embedding CUREs into standard courses across the curriculum, enabling students—regardless of major or class year—to participate in authentic research activities within credit-bearing classes. One of the most visible examples of the CUREs approach is the "Seafood Forensics" course, co-taught by faculty in biology and marine sciences. Students used DNA barcoding to analyze seafood advertised as locally-sourced across North Carolina, discovering that 34% of shrimp and 90% of red snapper samples were mislabeled—often substituted with imported or lower-value species. Their research (Korzik et al., 2020; Spencer et al., 2020) informed the development of a certification program for truthful seafood labeling. Students completed the full research cycle, including sample collection, PCR-based DNA amplification, sequencing, and species identification using genomic databases.

2) *Integrated Curricula (IC)* involved the creation of co-taught first-year seminars that integrate the arts and humanities with the sciences and foster interdisciplinary connections across campus. Courses are led by faculty from disparate disciplines and encourage students to explore scientific questions through cultural, social and historical lenses. One seminar, "How Do We See?" paired a physicist with an art historian to examine the science of vision alongside artistic representations. Another course, "Narrating Climate Change: Making the Global Personal," teamed English and geography faculty to analyze climate science through literature and personal narrative. These and other IC offerings allow students to synthesize

diverse modes of inquiry while challenging them to think critically about the assumptions of separate disciplines.

3) *Makerspace* integrated hands-on design and fabrication into the undergraduate curriculum by embedding semester-long projects into courses across disciplines, supported by a campus-wide network of makerspace facilities. As part of the QEP, makerspace courses were designed to explicitly connect making to disciplinary learning outcomes, and faculty were supported in developing, implementing, and assessing those connections. For example, in an introductory geology course, students investigated the impact of topography on local flooding by building physical 3D models. Rather than receiving this content through lectures and static images, students created terrain models, predicted water flow, and tested their predictions by simulating floods (Plenge et al., 2022). The QEP also supported end-of-term Maker Fairs, where students from both course-based and independent projects presented their work. These events aim to promote communication, peer learning, and public scholarship – reinforcing the value of making as a pedagogical tool embedded within the academic experience.

4) *Research Exposure Opportunities* provided the infrastructure to ensure that research experiences were available for all students. This initiative included a departmental faculty liaison program, "Research-Related Skills" (RRS) courses focused on developing research-related communication skills, a week-long research celebration, and undergraduate research consultant teams conducting one-semester projects under faculty guidance. To address the gap in students' ability to critically engage with primary research literature, the QEP supported the development of RRS courses grounded in the CREATE model (Consider, Read, Elucidate hypotheses, Analyze and interpret data, and Think of the next Experiment; Hoskins et al., 2007). This pedagogical framework offers a stepwise approach to deconstructing journal articles, helping students develop transferable skills in research literacy and scientific reasoning. In these courses, students worked through real research studies, often without knowing the results in advance. For example, in a psychology RRS course, students began by analyzing the structure and rationale of published introductions, identifying hypotheses, and mapping experimental designs. As the semester progressed, they interpreted complex data figures, critiqued methods and conclusions, and ultimately designed follow-up experiments. This process-oriented model demystified the research enterprise and fostered a more active, inquiry-driven stance toward reading scientific literature.

The QEP Leadership Team was formed to serve as a decision-making body to supervise the process and actualization of the QEP initiatives. Each initiative had a program leader, a faculty professional development plan, and a detailed assessment plan designed in collaboration with the QEP Assessment Team.

The QEP underwent one significant change early in implementation: a shift from its original science-focused emphasis to a broader, interdisciplinary scope. Increasing interest among faculty across diverse disciplines, along with early positive outcomes from QEP-supported courses, prompted the QEP

Leadership Team to expand the initiative beyond STEM. As a result, the Leadership Team began receiving a wide range of course proposals and facilitating interdisciplinary collaborations that had not been initially anticipated. To reflect this expanded vision, the QEP was rebranded as simply “Learning by Connecting, Making, and Doing.”

The timing of this renaming coincided with a discussion across campus to create a common definition of “research” across disciplines. A campus-wide dialogue led to the decision that all undergraduates should engage in research before they graduate. This commitment is reflected in the new IDEAS in Action General Education curriculum, implemented in Fall 2022, which includes a requirement that students “immerse themselves in a research project, incorporating reflection and revision to produce and disseminate original scholarship or creative work” (Office of Undergraduate Curricula, n.d.).

Literature Review

Undergraduate research experiences have been widely recognized as contributing significantly to student learning, engagement, and preparation for future careers or graduate studies (Kuh, 2008; Lopatto, 2007). These experiences have been shown to improve critical thinking skills, increase retention in STEM fields, and enhance preparation for graduate studies (Russell et al., 2007; Seymour et al., 2004). However, traditional mentored research experiences often reach only a small percentage of students, typically those who are already high-achieving or have the social capital to seek out such opportunities (Bangera & Brownell, 2014).

Research Self-efficacy

Research self-efficacy, defined as students’ belief in their ability to perform key research tasks, has been identified as a critical factor influencing persistence in research careers (Bandura, 1997; Chemers et al., 2011). Participation in undergraduate research experiences has been shown to enhance students’ research self-efficacy, which in turn promotes greater engagement, resilience, and academic identity development (Lopatto, 2004; Russell et al., 2007). Given the QEP’s goal of broadening research participation and strengthening research skills, measuring gains in research self-efficacy was an important aspect of the assessment plan.

Course-based Undergraduate Research Experiences

Course-based Undergraduate Research Experiences (CUREs) have gained recognition as an effective method for expanding research opportunities (Auchincloss et al., 2014). CUREs integrate authentic research experiences into the curriculum, allowing more students to engage in the process of scientific inquiry within the structure of a course. Research has demonstrated that CUREs can provide benefits comparable to traditional mentored research experiences, such as enhanced scientific self-efficacy and a deeper understanding of the nature of science (Corwin et al., 2015; Brownell et al., 2015). The impact of CUREs on student learning outcomes has been well-documented across various disciplines. For instance, in biology, CUREs have been shown to enhance students' ability to interpret data and understand the process of scientific discovery (Brownell et al., 2012). In chemistry, CUREs have led to improved problem-solving skills and increased interest in research careers (Weaver et al., 2008).

However, most studies have focused on STEM fields, and there is a need for more research on the implementation and impact of CUREs in humanities and social sciences (Shanahan et al., 2015).

Makerspaces

Makerspaces have gained popularity in higher education as a means to promote hands-on learning and interdisciplinary collaboration (Barrett et al., 2015). These spaces provide students with tools and resources to design, prototype, and create, fostering innovation and creativity. While research on the integration of makerspaces into undergraduate curricula is still emerging, early studies suggest positive impacts on student engagement, problem-solving skills, and self-efficacy (Halverson & Sheridan, 2014). At the time the QEP was developed, UNC already had a robust network of functioning makerspaces. However, their use was not systematically integrated into academic coursework. Many students primarily associated making with extracurricular activities or 3D-printed decorative objects.

Integrated curricula

Integrated curricula initiatives have gained attention for their role in helping students make connections across disciplines and develop more holistic problem-solving skills (Holley, 2009; Repko et al., 2014). By intentionally linking concepts from multiple fields, integrated curricula are associated with deeper learning, greater critical thinking, and enhanced cognitive flexibility (Newell, 2001). Research suggests that interdisciplinary course designs encourage students to transfer knowledge across contexts, better preparing them for complex, real-world challenges (Lattuca, Voigt, & Fath, 2004). In the context of undergraduate research, embedding inquiry-based experiences within integrated curricula frameworks offers students early and accessible entry points into research thinking across fields, beyond traditional disciplinary silos.

Research Exposure Opportunities

Providing structured exposure to research opportunities early in students' academic careers has been shown to foster interest in scholarly inquiry and improve retention in research pathways (Russell, Hancock, & McCullough, 2007; Kardash, 2000). Programs that highlight research opportunities through workshops, project showcases, and introductory seminars have been linked to increased student engagement and confidence in pursuing independent research (Hunter, Laursen, & Seymour, 2007). Research exposure opportunities are particularly important for broadening participation among historically underrepresented students by making research experiences visible, accessible, and less dependent on informal networks or prior knowledge (Hathaway, Nagda, & Gregerman, 2002). Embedding such opportunities within the curriculum helps normalize research engagement as an integral part of the undergraduate experience.

Assessment Methods

The assessment of undergraduate research experiences has evolved in recent years, with a growing emphasis on measuring not only content knowledge but also research skills, scientific identity, and career aspirations (Linn et al., 2015). Instruments such as the Laboratory Course Assessment Survey

(LCAS) and the Project Ownership Survey have been developed to capture these multifaceted outcomes (Corwin et al., 2015; Hanauer & Dolan, 2014). Although the advantages of undergraduate research experiences are well-documented, questions remain about how to implement and assess these experiences at scale, while also maintaining quality and addressing issues of equity and access (Eagan et al., 2013).

This study contributes to the growing literature by examining the implementation and impact of a comprehensive, institution-wide approach to integrating research experiences across disciplines. A combination of direct and indirect measures was used to assess the QEP's impact, including pre- and post-course tests, validated survey instruments, rubric-based scoring of student artifacts and presentations, and institutional participation data. Student outcomes were assessed in three key areas: (1) communication and collaboration skills, (2) understanding of the research process, and (3) development of research skills. In addition, we examined overall student engagement across disciplines. Assessment approaches were tailored to the specific goals of each initiative, although some measures, such as participation in Expo events and research self-efficacy surveys, spanned multiple initiatives. Table 1 summarizes the assessment strategies, including the initiatives assessed, tools used, the timing of data collection, scoring methods, and whether the measures were direct or indirect.

Table 1

Summary of Assessment Strategies for the QEP

Initiative	Measure/Tool	Timing	Scoring Method	Measure Type
Integrated Curricula (IC)	Enrollment data, Student reflections	Annual (Fall/Spring terms)	Participation counts, qualitative reflections	Indirect
Course-based Undergraduate Research Experiences (CUREs)	Expo rubric	End-of-course/expo presentations (annual)	Rubric-based ratings by faculty, peers, community	Direct & Indirect
	Pre/post content knowledge tests	Pre/post tests (semester-based)	Paired-sample statistical tests	Direct
	Laboratory Course Assessment Survey (LCAS)	Post-course surveys (semester-based)	Likert scale subscales (Collaboration, Discovery, Iteration)	Indirect
	Project Ownership Survey	Post-course surveys (semester-based)	Likert scale scores (personal investment, responsibility)	Indirect
	Research Self-Efficacy Scale	Pre/post surveys (semester-based)	Pre/post comparison on - Likert scales	Indirect
Makerspace Integration	Expo rubric	End-of-course/expo presentations (annual)	Rubric-based ratings by faculty, peers, community	Direct & Indirect
	Pre/post content knowledge tests	Pre/post tests (semester-based)	Paired-sample statistical tests	Direct

	Making Course Assessment Survey (MCAS)	Pre/post surveys (semester-based)	Subscales: collaboration, discovery, ownership, self-efficacy	Direct & Indirect
	Project Ownership Survey	Post-course surveys (semester-based)	Likert scale scores (personal investment, responsibility)	Indirect
	Research Self-Efficacy Scale	Pre/post surveys (semester-based)	Pre/post comparison on Likert scales	Indirect
Research Exposure Opportunities	Expo Rubric	End-of-course/expo presentations (annual)	Rubric-based ratings by faculty, peers, community	Direct & Indirect
	Pre/post content knowledge tests	Pre/post tests (semester-based)	Paired-sample statistical tests	Direct
	Research Self-Efficacy Scale	Pre/post surveys (semester-based)	Pre/post comparison on 5-point Likert scales	Indirect
All Initiatives	Participation counts (QEP courses/Expo events)	Annual review (over five years)	Enrollment and participation tallies	Indirect

Expo Rubric Assessments

Students participating in the QEP Expo events were evaluated using a standardized rubric designed to assess communication of project features, demonstration of novelty, and evidence of project ownership. The Expo Rubric was developed internally by the QEP Assessment Team in alignment with QEP learning goals. The rubric items were refined collaboratively with faculty input to ensure relevance across disciplines. Artifacts were scored during Expo events by faculty members, peers, and community partners, providing a triangulated evaluation of student presentations. Rubric assessments provided a direct measure of students' ability to articulate and reflect on their research experiences to a broader audience.

Pre/Post Content Knowledge Tests

Pre- and post-tests were administered in selected QEP courses to measure gains in disciplinary content knowledge. Tests included multiple-choice and short-answer items developed in alignment with course-specific learning objectives. These direct assessments allowed for quantifiable measurement of knowledge acquisition tied to research-intensive curricula.

Laboratory Course Assessment Survey (LCAS)

The LCAS (Corwin et al., 2015) is a validated instrument designed to measure student experiences in undergraduate research courses, focusing on collaboration, discovery and relevance, and iteration. It was adopted to capture key pedagogical elements of CUREs known to foster research engagement and persistence in STEM fields. The LCAS was adapted for use across QEP-supported CURE courses to measure students' perceptions of course features associated with authentic research experiences. This 17-item instrument includes three subscales: Collaboration, Discovery, and Iteration. Each subscale reflects a core pedagogical element that distinguishes CUREs from traditional laboratory or lecture-based courses.

- Collaboration (6 items) assesses how frequently students worked in teams and provided peer feedback. Responses are captured on a 4-point frequency scale (1 = Never to 4 = Weekly), with subscale scores ranging from 6 to 24.
- Discovery (5 items) evaluates the extent to which students generated original results and constructed new interpretations, using a 6-point Likert scale (1 = Strongly Disagree to 6 = Strongly Agree), yielding a subscale score range of 5 to 30.
- Iteration (6 items) captures how often students revised or repeated procedures to refine their work, also using a 6-point Likert scale, for a subscale score range of 6 to 36.

The total LCAS score is the sum of the three subscales, with a possible range of 17 to 90.

Project Ownership Survey

The Project Ownership Survey (Hanauer & Dolan, 2014) measures students' personal investment and sense of responsibility for research projects. Project ownership is considered a critical indicator of deep engagement and sustained research identity development, making this instrument appropriate for evaluating the QEP's focus on authentic student-driven inquiry. Students' sense of ownership over their research projects was assessed using this 10-item Project Ownership Survey (Hanauer & Dolan, 2014). The survey evaluates dimensions of personal investment, autonomy, and engagement in the research process using a 5-point Likert scale.

Research Self-Efficacy Scale

Students' research self-efficacy was assessed using a 7-item survey adapted from Chemers et al. (2011), a widely used tool for evaluating perceived ability to perform essential research skills. Increases in self-efficacy are associated with greater persistence in research pathways and were a central focus of QEP assessment. Administered as a pre- and post-course survey, the scale uses a 5-point Likert format to assess abilities such as developing research questions, analyzing data, and using research literature effectively.

Making Course Assessment Survey (MCAS)

The MCAS was developed at UNC to assess student experiences in Makerspace-integrated courses, including collaboration, discovery, ownership, and research self-efficacy dimensions. The tool was specifically tailored to the design/fabrication context of makerspace environments while maintaining alignment with broader undergraduate research engagement constructs. The instrument was designed to align with QEP learning goals and to fill a gap in validated tools that capture the educational impact of design/fabrication learning environments. MCAS includes multiple subscales assessing students' experiences with collaboration, discovery, and iteration, project ownership, and self-efficacy.

Institutional Participation Data

Enrollment and participation data were collected annually to track the reach of QEP initiatives across courses, departments, and student populations. These data provided an indirect measure of institutional engagement and the scalability of research opportunities created through the QEP.

Data Analysis

Pre- and post-test gains in content knowledge, research self-efficacy, and project ownership were analyzed using paired-sample t-tests. Data were screened for extreme outliers, and assumptions of normality were assessed through descriptive statistics. Minor deviations were considered acceptable given sample sizes were above 30 participants. Effect sizes (Cohen's d) were calculated to estimate the magnitude of observed differences.

Faculty Development and Program Capacity Building

In addition to assessing student learning outcomes directly, the QEP placed a strong emphasis on faculty development and program-level capacity building to sustain undergraduate research opportunities. Faculty Learning Communities (FLCs), leadership support, and embedded assessment practices were central to these efforts. The following section outlines the strategies implemented to engage faculty, build institutional capacity, and integrate research-focused pedagogy across disciplines.

Faculty Development

In some large university learning projects, data collected is never seen by the faculty or other people working with students. Our QEP was implemented differently, and evolved over time, to better utilize the data we collected. For example, faculty took a parallel survey to the student survey in CURE and makerspace courses. We shared the survey results with faculty and helped them reflect on the results, such as asking, 'What does it mean if your students think that the course is less about collaboration than you do?". Discussions like this led to faculty redesigning courses, speaking with students more explicitly about course intentions, or better training TAs to teach these courses.

Beyond individual courses, the QEP used data to better support overall learning. For example, during the QEP Expo it became clear that although we had a mechanism to provide feedback to students using the Expo Rubric, we could get additional peer feedback and help faculty teach students how to improve communication about their research. Subsequently, we found ways to encourage more student peers to complete the rubric at the QEP Expo and to assist the makerspace program in improving student communication about their projects. Before our last makerspace event, QEP faculty spent class time helping students practice how to communicate about their projects, from articulating their initial development and iteration approach to prototyping and refinement.

Program Capacity Building

As we began thinking about course proposals and reading literature about how successful, sustainable systemic changes were made institutionally in higher education, we implemented a robust professional development plan across the programs that had course development funds. Specifically, we began year-long participation in FLCs as a stipulation for funds in the CURE, RRS, and Makerspace programs. These FLCs not only helped faculty build better courses via the material discussed, but they had a big impact on building a campus community across disciplines around undergraduate learning. On the student impact side, the Reading Scholarly Literature Scale was used to assess students' growth in RRS.

Significant pre/post gains were observed across multiple items, particularly in evaluating arguments, interpreting data visualizations, and navigating technical language.

Engaged Assessment Model

Over time, an innovative "engaged assessment" model emerged through the QEP. This engaged assessment model, as described by Hutson & Hogan (2023), was designed to increase faculty involvement and ownership in the assessment process, addressing the common challenge of limited faculty engagement in assessment at doctoral research universities (Grunwald & Peterson, 2003; Jankowski et al., 2018; Kuh & Ikenberry, 2009). The engaged assessment model can be understood through four key aspects: structure, process, product, and sustainability (Hutson & Hogan, 2023), as described below.

Structurally, the model centered on the FLCs, which Hutson & Hogan (2023) identified as crucial for bringing together faculty from diverse disciplines and assessment professionals. These FLCs provided a platform for cross-disciplinary collaboration and dialogue, encouraging boundary crossing and shared problem-solving around common student learning outcomes (Cox, 2003; Hutson & Downs, 2015).

The process aspect incorporated design thinking principles, emphasizing iteration and adaptability (Benson & Dresdow, 2014; Brown, 2008). Faculty engaged in activities of inspiration, ideation, and implementation. This approach allowed for the development and adaptation of common assessment measures, such as the LCAS, which was modified for use across different disciplines (Corwin et al., 2015).

In terms of product, the model emphasized immediate and meaningful use of assessment data. Ongoing dialogues between faculty and assessment professionals focused on interpreting data to inform program innovations and assessment adaptations. This resulted in program improvements, instructor development, and continuous enhancement of assessment practices throughout the five-year QEP (Hutchings et al., 2011; Wehlburg, 2008).

The sustainability of the model was ensured through mutual learning and capacity building. By reframing assessment as scholarship, faculty were encouraged to view it as an integral part of their academic work rather than an administrative burden (Hutchings et al., 2011). This led to enhanced collaborative assessment capacity across the institution and contributions to the Scholarship of Teaching and Learning (SoTL), with faculty producing publications and presentations based on their assessment efforts (Cruz et al., 2020; Rivard, 2019; Spencer et al., 2020).

Overall, this engaged assessment approach not only provided valuable data on the effectiveness of the QEP but also fostered a culture of assessment and continuous improvement among faculty. It successfully bridged the gap between classroom practice and institutional assessment, making the process more meaningful and impactful for both faculty and students (Hutson & Hogan, 2023; Kinzie et al., 2019). The success of the model was evidenced by increased faculty participation in assessment activities, the adaptation of assessment tools for use in non-traditional CURE disciplines, and the generation of SoTL publications stemming from these assessment efforts (Sathy et al., 2021).

Impact on Student Learning

A variety of assessment methods and instruments were identified for measuring the institutional outcomes relative to the scope of the QEP, its initiatives, and the student learning outcomes. The assessment plan includes three data types: (1) measures of content knowledge and development of research skills, (2) measures that illustrate development of greater student empowerment and efficacy in conducting research, and (3) institutional data that illustrates the greater participation and increased diversity of students impacted.

Content Knowledge and Development of Research Skills

Offering students more opportunities to engage in research involved a wide range of disciplines. Consequently, this assessment of student learning required faculty collaborating with the QEP Leadership and Assessment teams to develop discipline-appropriate measures. These efforts led to expanded dialogues about assessment and supported the creation of faculty learning communities that considered assessment alongside course development to identify suitable direct measures.
The examples below illustrate the assessment of content knowledge from a CURE, Maker, and RRS course. In each of the three courses, a growth in content knowledge was noted.

CURE Example – CHEM 262L: Organic Chemistry CHEM 262L is a multi-section organic chemistry lab course that enrolls approximately 700 students annually. CURE objectives were incorporated into the course to provide students with authentic research experiences, following an initial phase of scripted lab experiments designed to familiarize them with essential chemistry techniques. This structured transition allowed students to apply their newly acquired skills within the context of the CURE project. Student learning was assessed using a 10-item pre- and post-test measuring knowledge of key organic chemistry concepts. Across semesters, results demonstrated a statistically significant improvement in content knowledge, with average scores increasing from 37.9% on the pre-test to 56.8% on the post-test.

Maker Example –Physics 100: How Things Work This Introduction to Physics course uses everyday mechanisms or activities to teach fundamental concepts in physics at UNC. A signature requirement of the course is to design and construct a time-keeping device featuring a strong artistic element at one of the makerspaces on campus. The pre- and post-test administered in this course addressed common misconceptions related to physics. Across the semesters the course was offered through the QEP, an increase in student understanding of physics concepts was noted (35.1% average percentage correct on the pre-test; 42.3% average percentage correct on the post-test).

RRS Example – EXSS 397: Critical Analysis of Literature in Sport and Exercise Psychology This course introduces students to research in sport and exercise psychology by analyzing historical publications from a specific research group over time, aiming to deepen their understanding of the research process. After this review, students develop their own novel research questions and present them to the class. Assessment of student learning was conducted through a pre- and post-test focused on concepts and practices in research design. Across semesters, results showed a statistically significant improvement in content knowledge, with average scores increasing from 62.2% on the pre-test to 92.2% on the post-test.

QEP Expo. The QEP Expo offered the opportunity for students to share their original work. Over the course of the QEP, over 2,000 students from 96 classes participated in the Expo, presenting original research and creative work. These Expo experiences provide students with the opportunity to showcase their enhanced communication and collaboration skills as active members of research teams. At these events, over 1,000 members of the University community provided feedback on student projects using a brief rubric that addressed Project Features, Project Novelty, and Project Ownership, as shown in Table 2 below.

Table 2

Expo Rubric Scores from University Community Members

Rubric Item	**1** *Developing*	**2** *Acceptable*	**3** *Exceptional*	**Mean Research Project Score**	**Mean Maker Project Score**
Communicate about key features of their project	Student or group was unorganized in thoughts. While they may provide some details, a clear overview about why they did the project, the process involved, and the significance of the outcome was missing or lacking.	Student or group presented a clear overview about why they did the project, the process involved, and the significance of the outcome.	Student or group presented a clear overview about why they did the project, the process involved including aspects of troubleshooting failure, and the significance of the outcome.	2.85	2.72
Explain how their project was novel	Student or group did not address novelty in their presentation, were not aware of how their project was novel when asked or stated that it wasn't particularly novel.	Student or group explained how their project resulted in new knowledge, new questions, or a novel object.	Student or group explained how the new knowledge, new questions, or a novel object produced was a response to a problem or gap in knowledge.	2.80	2.75

Demonstrate project ownership	Student or group did not demonstrate that they had opportunities to make choices in their project that could fail.	Student or group demonstrated one example of an opportunity to make choices in their project that could fail.	Student or group demonstrated multiple examples of an opportunity to make choices in their project that could fail OR demonstrated enthusiasm and significance around one example.	2.86	2.80

Note. Scores reflect ratings from 1,025 university community members evaluating 264 student projects presented at QEP Expo events.

Student work was also evaluated at the Expo by content experts. Table 3 shows the use of rubrics to score a sample of posters from CURE courses, comparing the work from STEM and Humanities CUREs.

Table 3

Poster Rubric Scores from Content Experts

Rubric Item	**0** *Not Evident*	**1** *Emerging*	**2** *Clearly Demonstrated*	**CURE STEM**	**CURE Humanities**
Collaboration	Unclear	In one part of the project (i.e., data collection or peer review only)	Worked as groups through semester or in more than one part of the project	2.00	1.43
Discovery	It is unclear if any part of the research process or findings are novel discoveries or is not novel or not addressed.	It is clearly stated what is novel about the project at least once.	Novelty and discovery are clearly stated multiple times.	1.13	1.24
Relevance	Unclear or not addressed	Students hinted at what is more broadly relevant about the research area to a larger audience.	Students clearly stated what was broadly relevant about the research area to a larger audience.	1.44	1.62
Applied disciplinary research practices	Unclear or not addressed	Described practices briefly or vaguely	Described practices clearly.	1.87	1.52

Note. Scores reflect evaluations of 83 student research posters by faculty content experts using the CURE Poster Rubric.

In addition to forums such as the QEP Expo, students engaged collaboratively in research and communicated their work by writing up their findings, submitting their work to academic journals, experiencing the peer-review process, and ultimately publishing their work. We expect many more publications to come from the current projects as the courses continue. For example, after describing the novel findings from her students, one neuroscience instructor noted: "Data collected will be part of a larger scientific story after several more semesters of teaching the course." This observation highlights the sustainability of the discovery aspect of a CURE course, building upon itself from semester to semester.

The impact of student discoveries goes beyond peer-reviewed work and often directly impacts the community as well. For example, in a public policy senior capstone course, a report called "Women in Pittsboro and Chatham County" was used by the Chatham Community Library when organizing a forum about women's perspectives on the county. Additionally, students in an ecology course conducted water testing, working with the University's stormwater engineer on a restoration project, while students in an anthropology course worked with Warren County residents on themes of memorialization and remembrance as part of a project about the descendants of lynching victims.

Table 4 highlights some of the peer-reviewed papers that were published from CUREs over the course of the QEP.

Table 4

Peer-Reviewed Articles Stemming from Student Discovery in CURE Courses

Class Number & Name	Published Articles
Biology 221L: The Evolution of Extraordinary Adaptations	Davis A. L., Babb, M. H., Lowe, M. C., Yeh, A. T., Lee, B. T., & Martin, C. H. (2019). Testing Darwin's hypothesis about the wonderful Venus Flytrap: Marginal spikes form a "horrid prison" for moderate-sized insect prey. *American Naturalist, 193*(2), 310-317.
Chemistry 445: Electroanalytical Chemistry	Glasscott, M. W., Verber, M. D., Hall, J. R., Pendergast, A. D., McKinney, C. J., & Dick, J. E. (2020) SweepStat: A build-it-yourself, two-electrode potentiostat for macroelectrode and ultramicroelectrode studies. *Journal of Chemical Education, 97*(1), 265–270.
Biology 221L: Food Mislabeling Lab: Seafood Forensics	Spencer, E. T., Richards, E., Steinwand, B., Clemons, J., Dahringer, J., Desai, P., Fisher, M., Fussell, S., Gorman, O., Jones, D., Le, A., Long, K., McMahan, C., Moscarito, C., Pelay, C., Price, E., Smith, A., VanSant, A., & Bruno, J. F. (2020). A high proportion of red snapper sold in North Carolina is mislabeled. *PeerJ, 8*, e9218. https://doi.org/10.77f17/peerj.9218. Korzik, M.L., Austin, H.M., Cooper, B. Jasperse, C., Tan, G., Richards, E., Spencer, E.T., Steinwand, B., Fodrie, F. J., & Bruno, J. F. (2020).

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Psychology 438: Research Topics in the Psychology of Language	Arnold, J. E., Mayo, H.C., & Dong, L. (2021). My pronouns are they/them: Talking about pronouns promotes singular they. *Psychonomic Bulletin and Review*, *28*, 1688–1697. https://doi.org/10.3758/s13423-021-01905-0.
Biology 423: Laboratory Experiments in Genetics	Cook, D., Long, S., Stanton, J., Cusick, P., Lawrimore, C., Yeh, E., Grant, S., & Bloom, K. (2021). Behavior of dicentric chromosomes in budding yeast. *PLoS Genet, 17*(3), e1009442. https://doi.org/10.1371/journal.pgen.1009442.

Additionally, the QEP Integrated Curricula courses transitioned into Ideas, Information, and Inquiry (Triple-I) courses starting in the spring of 2019 and are now required of all incoming UNC students. Higher rates of enrollment in Triple-I course offerings have greatly broadened students' exposure to cross-disciplinary research early in their academic careers. Students who participated in these courses agreed that they were better able to: (1) describe how different disciplines addressed the same research question with different approaches, and (2) understand people's behaviors in the context of their own culture. Further, students who took Triple-I courses commented on the benefits of having more than one instructor. One student explained, "It was like keeping an open mind, with each perspective playing into and complementing each other. It felt like a complete 360 view, rather than just one side."

Development of Empowerment and Efficacy in Conducting Research

Understanding student growth in these areas is highly dependent on student self-reported data that captures self-perception, attitudes, and metacognition. To this end, surveys were developed to capture: (1) student experiences with research and making, (2) sense of ownership of the various research and making projects, and (3) sense of efficacy in conducting research or design and in creating maker projects.

CUREs

Across all QEP-supported CUREs, assessment data from the LCAS and the Project Ownership Survey showed consistently high levels of student engagement, collaboration, and personal investment. These findings affirm that CUREs can support both disciplinary learning and the development of research identity, making research more accessible and meaningful for a wider range of undergraduates.

A total of 2,763 STEM students and 612 humanities students completed the LCAS (Table 5). Average scores were high across all three subscales, with humanities students reporting slightly higher mean scores than their STEM peers. For example, the mean scores for Collaboration were 19.87 (Humanities) and 19.01 (STEM); for Discovery, 25.08 vs. 22.38; and for Iteration, 29.59 vs. 26.69. Total LCAS scores averaged 76.22 for humanities and 68.03 for STEM.

Compared to national benchmarks from the LCAS validation study, QEP students—especially those in humanities-based CUREs—reported elevated levels of collaboration, engagement in discovery, and iterative research. These findings affirm that CUREs can successfully replicate the core elements of authentic research experiences across disciplines, and that faculty-led, course-embedded models have the potential to democratize access to meaningful undergraduate research.

Table 5

LCAS Scores of QEP Students

LCAS		STEM Courses		Humanities Courses	
Subscale	Score Range	Mean	SD	Mean	SD
Collaboration	6-24	19.01	4.84	19.87	3.69
Discovery	5-30	22.38	4.90	25.08	4.43
Iteration	6-36	26.69	5.81	29.59	4.57
Overall Score	17-90	68.03	12.49	76.22	8.50

Note. A total of 2,763 STEM CURE students and 612 Humanities CURE students completed the Laboratory Course Assessment Survey (LCAS) following participation in QEP-supported CURE courses.

Project Ownership

Post-course data were collected from 2,763 STEM students and 612 humanities students participating in QEP-supported CUREs via the 10-item Project Ownership Survey (Table 6). Results show that students across both domains reported strong ownership experiences. In both groups, the highest ratings were observed for items related to personal responsibility (e.g., “I was responsible for the outcomes of my research”) and personal achievement (e.g., “The findings of my research gave me a sense of personal achievement”). Humanities students consistently reported slightly higher mean scores than STEM students across most items, especially on measures reflecting emotional engagement and interest in the research project. These results suggest that QEP-supported CUREs promoted a strong sense of ownership, an important precursor to research identity and persistence.

Table 6

Project Ownership Scores of QEP Students

Project Ownership Survey Items	STEM Courses		Humanities Courses	
	Mean	SD	Mean	SD
1. My research will help to solve a problem in the world.	3.33	.97	3.37	.94
2. My findings were important to the research community.	3.35	.96	3.56	.88
3. I faced challenges that I managed to overcome in completing my research project.	3.38	1.05	3.87	.70
4. I was responsible for the outcomes of my research.	3.82	.91	4.06	.76
5. The findings of my research project gave me a sense of personal achievement.	3.48	1.05	3.74	.89

6. I had a personal reason for choosing the research project I worked on.	3.50	1.12	3.83	.85
7. The research question I worked on was important to me.	3.57	1.00	3.85	.93
8. In conducting my research project, I actively sought advice and assistance.	3.68	1.00	4.06	.81
9. My research project was interesting.	2.85	1.20	3.70	1.08
10. My research project was exciting.	3.85	.93	3.91	.818

Note. A total of 2,763 STEM CURE students and 612 Humanities CURE students completed the Ownership Scale following participation in QEP-supported CURE courses.

Research Self-efficacy

Students' confidence in performing essential research skills was measured through a 7-item Research Self-Efficacy Scale adapted from Chemers et al. (2011).

Data from 2,211 students (Table 7) showed statistically significant increases on all seven items ($p <$ .001). The largest gains were observed in students' ability to use literature to guide research (effect size = 0.64), generate research questions (0.47), and communicate results via poster or paper (0.49). These findings indicate that participation in research-rich coursework, especially CUREs and Makerspace projects, fostered measurable increases in students' research self-efficacy. Given the association between self-efficacy and long-term engagement in research pathways, these gains are a meaningful outcome of the QEP.

Table 7

Research Self-Efficacy Scale Scores of QEP Students

	Pre-		Post-			
"I am confident…"	Mean	SD	Mean	SD	Significance	Effect Size
1. I can use research tools, instruments, and techniques.	3.81	.77	4.02	.80	< .001	0.267
2. I can generate a research question to answer.	3.66	.85	4.04	.76	< .001	0.471
3. I can create explanations for the results of the study.	3.83	.78	4.01	.76	< .001	0.234
4. I can use research literature and reports to guide my research.	3.62	.83	4.12	.72	< .001	0.644
5. I can develop theories by integrating results from multiple studies.	3.60	.89	3.99	.78	< .001	0.466
6. I can communicate my work through a poster and/or paper.	3.59	.84	3.99	.80	< .001	0.488
7. I can figure out what data/observations to collect and how to collect them.	3.75	.76	4.01	.78	< .001	0.338

Note. A total of 2,211 students completed both the pre- and post-survey versions of the Research Self-Efficacy Survey while participating in QEP-supported CURE courses.

Makerspace

A total of 1,649 students completed the MCAS after participating in QEP-supported makerspace courses. Scores on the collaboration and discovery/iteration subscales showed strong means (Table 8), reflecting student engagement with creative problem-solving, teamwork, and iterative design processes (Collaboration: M = 21.04, SD = 18.78; Discovery/Iteration: M = 38.70, SD = 15.05).

Project ownership was also assessed using an embedded 8-item scale. Students most strongly endorsed items related to responsibility and achievement (e.g., “I was personally responsible for the outcomes of my project,” M = 4.22; “The outcomes of my project gave me a sense of personal achievement,” M = 4.23), indicating a high level of personal investment and connection to their projects (Table 9).

Self-efficacy was assessed using a 5-item pre/post scale focused on technical making skills (Table 10). Statistically significant gains were observed across all items ($p < .001$), with effect sizes ranging from 0.39 to 0.58. Students reported increased confidence in designing, fabricating, and explaining their projects—for example, “I can fabricate something I have designed myself” increased from M = 3.66 to M = 4.14 (effect size = 0.56).

Collectively, these results suggest that makerspace courses supported by the QEP offered robust learning environments that fostered creativity, skill development, and project engagement.

Table 8

MCAS Subscale Scores of QEP Students

MCAS Subscale	Scores Mean	SD
Collaboration	21.04	18.78
Discovery/Iteration	38.70	15.05

Note. A total of 1,649 students completed the Making Course Assessment Survey following their participation in QEP-supported Makerspace courses.

Table 9

MCAS Ownership Scale Scores

Maker Ownership	Mean	SD
1. My project will help to solve a real-world problem.	3.19	1.10
2. My project outcomes will have an important impact.	3.23	1.09
3. I overcame challenges in completing my project.	4.18	.78
4. I was personally responsible for the outcomes of my project.	4.22	.77

5. The outcomes of my project gave me a sense of personal achievement.	4.23	.83
6. I had a personal reason for choosing the project I worked on.	3.61	1.10
7. The project I worked on was important to me.	3.82	.97
8. In creating my project, I actively sought advice and assistance.	3.93	.89

Note. A total of 1,649 students completed the MCAS Ownership Scale following their participation in QEP-supported Makerspace courses.

Table 10

MCAS Self-Efficacy Scale Scores

	Pre-		Post-			
"I am confident…"	Mean	SD	Mean	SD	Significance	Effect Size
1. I can use technical tools and techniques to make something new.	3.68	.91	4.11	.82	< .001	0.504
2. I can design a new tool or object to solve a problem.	3.61	.89	3.98	.88	< .001	0.423
3. I can fabricate something I have designed myself.	3.66	.89	4.14	.83	< .001	0.564
4. I can select the best materials among those available to create what I have designed.	3.47	.89	4.04	.82	< .001	0.578
5. I can explain what I have created to an audience.	3.93	.85	4.24	.75	< .001	0.392

Note. A total of 1,245 students completed both the pre- and post-survey versions of the MCAS Self-Efficacy Scale while participating in QEP-supported Makerspace courses.

Research-Related Skills

Results from 841 students enrolled in Research-Related Skills courses showed statistically significant increases on all the Reading Scholarly Literature Scale items ($p < .001$), with moderate to large effect sizes (Table 11). Students reported the greatest growth in their ability to critically analyze discipline-specific literature (effect size = 0.90), recognize sound arguments and evidence (0.81), and interpret scholarly jargon (0.81). Gains were also observed in students' ability to evaluate data presentations and identify research questions based on data. These findings suggest that structured, course-based instruction in research literacy can substantially improve students' confidence and competence in engaging with scholarly literature across disciplines.

Table 11

Reading Scholarly Literature Scale Scores

	Pre-		Post-			
	Mean	SD	Mean	SD	Significance	Effect Size
1. I understand how to critically evaluate studies conducted by others.	3.44	.80	4.14	.66	< .001	0.799
2. I understand how to look at data and figure out what question the researchers were asking.	3.77	.72	4.23	.70	< .001	0.618
3. Presently, I can critically analyze literature from my discipline.	3.52	.84	4.23	.68	< .001	0.903
4. Presently, I can recognize a sound argument and appropriate use of evidence in scholarly literature.	3.69	.76	4.24	.62	< .001	0.810
5. Presently, I can interpret the complex language and jargon in scholarly literature.	3.31	.92	3.99	.72	< .001	0.805
6. Presently, I am confident I can interpret data presented in graphs, tables or charts.	3.69	.86	4.16	.78	< .001	0.575
7. Presently, I am confident I can intelligently criticize other's ideas or proposals.	3.41	.91	4.06	.75	< .001	0.751
8. Presently, I am in the habit of thinking about whether I am fully understanding what I am reading when reading scholarly articles.	3.94	.78	4.30	.69	< .001	0.487

Note. A total of 841 students completed both the pre- and post-survey versions of the *Reading Scholarly Literature Scale* while participating in QEP-supported RRS courses.

Broadening Participation

The ramifications of having many faculty working together across disciplines ultimately benefited all students at the university through the new IDEAs in Action general education curriculum (launched Fall 2022). For example, by having to define measurable learning outcomes in a CURE course of any discipline, faculty had to agree that there were certain learning skills that transcended all disciplines, such as analysis of primary text or data. The exercise of defining a CURE laid the foundation for defining other "capacities" (e.g., Global Understanding and Engagement) that eventually became part of the general education curriculum. Further, many of the faculty involved in the QEP helped educate others about "capacities" thinking. Once the curriculum was approved, faculty involved in the QEP served as reviewers in the course approval process and took leadership roles in training colleagues on how to teach these capacities to students. The faculty set guidelines that at least 30% of class time needed to be spent practicing how to ask questions, collaborate, analyze collected data, and present findings. Thus, the QEP brought a new way of thinking about how common learning goals are defined and measured across all disciplines that will be sustained through the general education curriculum for years to come.

The university's previous QEP led to the creation of the Office for Undergraduate Research, which flourished over time but remained limited in scale. As we launched the current QEP, our vision expanded: we aimed to reach significantly more students by embedding research experiences throughout the curriculum—particularly through course-based opportunities. Unlike mentored research, which often requires social capital and can be inaccessible to students balancing work or family responsibilities, course-based research offers a more equitable and scalable pathway into the research enterprise. The QEP provided the infrastructure to support this vision, giving rise to the RRS and CURE programs and enabling sustained, structured engagement with research across disciplines. One lasting legacy of this work is the Research and Discovery requirement in UNC's IDEAs in Action curriculum, which ensures that every undergraduate—regardless of background or access—has the opportunity to graduate with meaningful research experience. Through this QEP, the university built the foundation for "research for all" at a leading public research institution.

Course enrollment data illustrate how the QEP increased participation in research: UNC's QEP initiative encompassed 227 unique classes in 41 subject areas and enrolled 14,080 students over the five-year period spanning from Fall 2017 to Spring 2022. Across the four programs, 49 new CUREs, 25 new Maker courses, 24 new RRS courses, and 14 new IC courses were introduced to the curriculum. In total, 33 academic departments were involved in the QEP.

Discussion

The development and implementation of the QEP were guided by several core questions: How can undergraduate research experiences be made broadly accessible across disciplines? How can research skill development and project ownership be fostered systematically within the curriculum? How can interdisciplinary engagement be promoted through structured research pathways? These guiding questions shaped both the design of the QEP and the strategies used to assess its impact.

Findings from the QEP demonstrate that large-scale, course-embedded research experiences can meaningfully expand access to undergraduate research while supporting key learning outcomes. Across a broad range of disciplines, students showed gains in content knowledge, reported increases in research self-efficacy, and demonstrated strong levels of project ownership. By embedding research within courses required for degree programs, the QEP reduced barriers historically associated with mentored research, promoting broader participation across demographic and disciplinary groups. These outcomes reflect the cumulative impact of integrating research opportunities into existing courses and intentionally supporting faculty in this work.

Notably, the QEP's emphasis on inclusivity yielded outcomes beyond its original STEM-centered goals. Faculty across departments embraced the opportunity to design research-rich learning experiences, and the resulting expansion required adaptation of support structures and assessment tools. This unanticipated level of engagement was a positive surprise and prompted the rebranding of the QEP to "Connecting, Making, and Doing" to reflect its broader reach.

The integration of assessment practices into program design proved essential. Faculty used feedback and results from rubrics, pre/post surveys, and reflective practices to refine course design and student support. Faculty Learning Communities helped foster sustainable, collaborative engagement in assessment across departments.

One of the most durable impacts of the QEP has been its contribution to the institutionalization of undergraduate research. The IDEAs in Action curriculum now includes a “Research and Discovery” requirement, reflecting the university’s broader commitment to embedding high-impact practices into the undergraduate experience. This transition from initiative to infrastructure demonstrates how a focused, well-supported QEP can serve as a catalyst for long-term change. The QEP experience demonstrated that even modest interventions – such as embedding a research project into a standard course – can lead to substantial gains in student learning outcomes when implemented systematically and supported institutionally. These findings suggest that course-based research models offer a scalable, sustainable approach to integrating inquiry-based learning across diverse disciplines.

Limitations

As with any institution-wide initiative, several limitations must be considered when interpreting the findings of this study. While the use of multiple assessment tools – including pre- and post-tests, surveys, and rubrics – offered valuable insight into student learning and engagement, these tools were not implemented uniformly across all QEP programs. Courses varied in how and when instruments were used, and as a result, the strength and comparability of the data varied by program area.

Participation in assessments was also voluntary in many cases, introducing the potential for response bias. Students who were more engaged in their coursework or particularly invested in their research experiences may have been more likely to complete assessments, potentially skewing results in a positive direction.

In addition, the absence of formal control or comparison groups limits the ability to draw strong causal conclusions. Although pre- and post-assessments indicated statistically significant gains, other factors—such as concurrent coursework, prior academic experiences, or developmental growth over time—may have contributed to those improvements.

Implementation fidelity also varied across instructors and departments. While faculty were supported through shared rubrics, professional development, and peer collaboration, the local context of each course shaped how QEP practices were adopted. These adaptations reflect both the flexibility and complexity of embedding research at scale.

The COVID-19 pandemic added additional challenges. Disruptions to instruction during remote semesters affected both student engagement and faculty capacity. Some planned assessment activities were not feasible during these terms, and response rates declined. Nevertheless, faculty adapted creatively with virtual CUREs and online research presentations.

Lastly, this study focused on near-term learning outcomes and did not track longer-term impacts such as persistence in research, graduate study, or workforce outcomes. Capturing these effects would require additional longitudinal data collection beyond the scope of the five-year QEP.

Despite these limitations, the study offers meaningful evidence of how a large public university can use course-based research models to enhance student learning, build faculty capacity, and promote institutional change. The findings contribute to a growing body of literature showing that research-rich learning can be effectively integrated into the curriculum when supported by thoughtful design and broad campus engagement.

Practical Applications and Future Directions

The QEP experience provides a useful model for institutions seeking to scale undergraduate research opportunities efficiently and equitably. Embedding research activities within required or widely accessible courses across disciplines can democratize access to high-impact educational practices. Key enabling structures included faculty learning communities, use of common rubrics, and intentional integration of assessment into course design-all of which can be adapted by other institutions.
The emergence of the Research & Discovery general education requirement highlights one strategy for scaling the impact of research initiatives beyond the life of a single project. Institutions might also consider aligning course-based research models with equity goals and strategic planning frameworks to ensure sustained support.

Future assessment efforts should incorporate longitudinal tracking to examine the longer-term effects of early research experiences on student academic and professional outcomes. Additionally, adapting CURE and Makerspace models to non-STEM disciplines and exploring links to workforce readiness may expand both reach and relevance.

Expanding interdisciplinary research experiences, promoting inclusive practices, and integrating research across the undergraduate experience will remain important priorities as higher education evolves. Course-embedded models, as demonstrated through the QEP, offer a promising path forward.

Conclusion

The Learning by Connecting, Doing, and Making QEP demonstrated that embedding research opportunities across the curriculum can substantially expand access, support skill development, and foster deeper student engagement. By integrating initiatives across diverse disciplines and course types, the project broadened participation in high-impact educational practices and built sustainable institutional capacity. Findings suggest that systematic, course-based approaches can yield meaningful gains in student learning outcomes while promoting more equitable access to research experiences.
As undergraduate education continues to evolve, strategies that link research, teaching, and interdisciplinary inquiry will remain vital to preparing students for the complex challenges of the future.

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