Undergraduate Research

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Utah Valley University Library
Question:
The primary issue is student involvement in undergraduate research and the impact on retention. Also, best practices for student involvement in undergraduate research.

Executive Summary:
Undergraduate research is essential to the development of capable professionals and productive adults. When combined with other traditional educational opportunities, undergraduate research helps develop and prepare students for success after graduation. "Undergraduate research is like role-playing. I mean no disparagement of the research -- role-playing is a critical part of life. Children learn how to be adults in part by trying on grown-up clothes and imitating a parent who is, say, driving a car or vacuuming a rug. Similarly, undergraduates can learn the conventions of research through imitation and practice" (Chapman, 2003, para. 7). It is often said that "practice makes perfect," but it is probably better said that practice makes prepared. "Through guided participation and extensive collaboration, long-term observation and practice, the novice researcher gradually acquires the skills and expertise needed for effective performance in the profession" (Adedokun, Dyehouse, Bessenbacher, & Burgess, 2010, p. 3).

Universities have to make undergraduate research happen regardless of on-campus resources and opportunities. Many schools are looking outwards to their larger communities in order to support student development. "Un fortunately, underfinanced public and urban institutions are among the least able to offer undergraduate research. One solution has been to create networks of off-campus research internships, often at elite universities interested in enhancing their diversity" (Carpi & Lents, 2013, para. 15). These opportunities should not be wholly extracurricular; they prepare graduates to get jobs. "For students entering the job market directly after graduation, a strong undergraduate research experience may substitute for "years of experience" (Hoffman, 2009, p. 22).

To be transformational, committed faculty and reasoned curriculum must drive undergraduate research programs. "The curriculum is the purview of the faculty and should be a direct expression of what faculty value in education. It is also one of the ways that faculty gain some control over time, which many regularly cite as their primary limiting resource. Balancing a scholarly agenda with heavy teaching commitments easily consumes available time, but utilizing the curriculum to better prepare undergraduates for independent research serves them well and prepares them to contribute to faculty members’ own scholarly work." (Eigren & Hensel, 2006, p. 4) As faculty are expected to do more with their time, changing expectations must be steadied with a commensurate change in compensation and resources.

Recognizing the impact of undergraduate research on student learning, student and faculty retention, and institutional reputation has led many institutions to respond with extraordinary support for undergraduate research. Colleges and universities have allocated and sometimes raised funds for student (and faculty) stipends, provided sabbatical leave programs to ensure continued scholarly
development for faculty members, reduced teaching loads, rewarded research mentoring activities with teaching credit, provided generous start-up packages for new faculty members, matched funds from external grants, and increased technical support for routine departmental tasks. (Eigren & Hensel, 2006, p. 5)

Undergraduate research must also be recognized for faculty in the official tenure and renewal process to be sustainable. “Unless there are formal procedures for rewarding UR in promotion, tenure, and renewal or strong evidence that faculty benefit in the form of increased scholarly productivity from mentoring, some form of compensation will be necessary for continued faculty enthusiasm for this work.” (Free, Griffiths, & Spellman, 2015, p. 5)

Time and again the mentoring relationship is emphasized throughout the literature. This relationships can be difficult to form, but individual contact and commitment can speed the process. “Research has shown that it takes one and a half to two years to establish a mentoring relationship in a university setting. In my experience, the liberal-arts setting, and especially a one-on-one research relationship, speeds up that process and is very effective at breaking down barriers between professors and students” (Zimmer, 2005, para. 16). Mentoring cannot be sporadic, it must be consistent to be impactful. “Even the best students need frequent contact with their advisor and constant mentoring to ensure that the project is making a genuine contribution” (Fenn, Johnson, Smith, & Stimpert, 2010, p. 13)

In order to impact retention, students need to be involved in research early and often. “Students who participate in research early, during the first year and second year, are more likely to succeed and graduate with college degrees in STEM disciplines. Such students are also likely to advance to graduate school in STEM areas or proceed to professional schools” (Fakayode, 2014, p. 663). Much of the literature focused on increased retention as one of the main benefits of undergraduate research. “Despite the difficulty of isolating the main effects of research opportunities from other activities the student is exposed to on campus, the descriptive evidence indicates that undergraduate research programs are a vital component of an integrated retention strategy for STEM students” (Hoffman, 2009, p. 22).

Universities need to broaden access to undergraduate research opportunities. These opportunities are often reserved for the best students. Haave and Audet (2013) encourage institutions to not only focus on high achievers. “Our data reveals that the majority of students with lower than average GPA earned relatively high grades in those research courses, hence receiving accrued benefits from the experience...Admission to UREs based only on prior GPA thus appears to be counter-productive by denying access to high impact educational experiences from students who would most benefit from it” (p. 4). Programs also need to be created for students who work. “Unfortunately, students who have financial constraints and must work are frequently not able to put the time needed into the labs in order to be prepared to perform their own research or contribute in a meaningful way to existing research projects. Therefore only certain students, specifically those with alternative means of supporting themselves, are currently participating and will be able to participate in the future” (Davis & Jacobsen, 2014, p. 24)

Undergraduate research is one of the best practices for helping minority and first-generation students succeed. “Since underrepresented minorities have higher rates of attrition and lower levels of academic performance to begin with, research participation may particularly help
prepare underrepresented minorities for graduate education and careers in the sciences, while providing a form of institutional integration into a competitive major at a large university” (Jones, Barlow, & Villarejo, 2010, p. 106) “Students who participate in undergraduate research early on report significant gains in the ability to (1) think analytically and logically; (2) put ideas together, and note similarities and differences between ideas; (3) learn on their own and to find information they need to complete a task. Moreover, it was found that early participation in collaborative research was of particular benefit for first-generation college students” (Ishiyama, 2002, para. 1).

The long-term impacts of undergraduate research are undeniable. It impacts learning. “The results also indicate that students involved in research projects demonstrate deeper learning through higher order thinking, integrative learning, and reflective learning” (Hoffman, 2009, p. 23). It impacts retention. “Programs that support high-impact practices, such as undergraduate research, should be viewed as investments that provide a rate of return through the retention of students” (Moran, Wells, & Smith-Aumen, 2015, p. 63). It prepares students for the future. “Student’s research work has been helpful in improving skills related to networking, improving professional credentials, and contributing to a body of knowledge. The skills from this subscale are skills that will help prepare undergraduates for their future careers” (Salsman, Dulaney, Chinta, Zascavage, & Joshi, 2013, p. 8). It creates a positive experience now and in the future. “A majority of respondents indicated that undergraduate research was a significant positive factor in their actual admission to graduate school, employment, or both.” (Schmitz and Havholm, 2015, p. 1) Most importantly though, when contrasted, there is no question that undergraduate research opportunities are a high-impact practice. “Two significant outcomes of this program are the long-term retention and higher GPAs of students compared with those in the matched control group throughout the students’ college experience” (Schneider, Bickel, & Morrison-Shetlar, 2015, p. 42).

Undergraduate research is a high-impact practice that is being formalized and instituted throughout the country. There are many strong ideas and best practices in the conclusions that were impossible to capture in a summary. There are three different sections of literature in the table below. Pages 3-61 focus on peer-reviewed articles that research the relationships, benefits, and difficulties of undergraduate research for students and faculty. Pages 62-98 focus on peer-reviewed articles that research retention and long-term outcomes of undergraduate research. Pages 98-105 are trade and professional articles.

**Peer-Reviewed Articles (Undergraduates and Faculty):**

<table>
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<tr>
<th>Citation</th>
<th>Abstract</th>
<th>Link</th>
<th>Limitations</th>
<th>Conclusions</th>
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<tbody>
<tr>
<td>1. Adedokun, O. A., Dyehouse, M., Bessenbacher, A., &amp; Burgess, W. D. (2010, April). <em>Exploring faculty perceptions of the benefits</em></td>
<td>A notable limitation in the extant and emerging literature on faculty-mentored undergraduate research is that the focus is often on the benefits to <a href="http://eric.ed.gov/?q=undergraduate+research+AND+faculty&amp;id=ED509729">http://eric.ed.gov/?q=undergraduate+research+AND+faculty&amp;id=ED509729</a></td>
<td>A study focuses on Faculty experiences in UR only. Small study group, only 18 Faculty members surveyed.</td>
<td>&quot;Through guided participation and extensive collaboration, long-term observation and practice, the novice researcher gradually...&quot;</td>
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| students' with little or no examination of the benefits and challenges to participating faculty. Using the cognitive apprenticeship model as a theoretical framework, descriptions of the benefits and challenges accruing to faculty are drawn from analysis of their responses to open-ended questions. Reported gains include "contribution to research agenda" and the personal satisfaction derived from enhancing students' professional growth while time constraints emerged as an important challenge. Although we cannot make generalizations beyond the scope and context of this qualitative study, the data provides some insight into the impact of mentoring undergraduate research on faculty. |
| acquires the skills and expertise needed for effective performance in the profession." (p. 3) |
| -- “It is hard to juggle everything and keep track of the student's performance when I am responsible for courses with combined enrollments that surpass 250 students.” (p. 7) |
| -- “Challenges for us--Better definition and understanding of what can be accomplished in a semester.” (p. 8) |
| -- “The main challenge was making the project straight-forward enough to fit within a relatively small number of hours per week over a semester.” (p. 8) |
| -- “Universities may need to provide incentives to faculty that devote time to mentoring UR.” (p. 9) |
| -- “ Also, faculty and |
students need to devise specific solutions tailored to address scheduling/timing constraints, e.g., while it is often impossible for faculty in research universities to have weekly one-one meetings with UR students, they may schedule mid or end of term meetings where goals and progress are discussed. “ (p. 9)


The article discusses the efforts of Oregon-based University of Portland (UP) to address the gap between their goal of developing morally minded students and provide them with opportunities to practice ethical behavior while pursuing scholarly activities. UP's programs include undergraduate research, moral formation and applied ethics, and formal ethical training. Other topics include ethical research behavior in biology and the


The article does not reference any impact of UR on Student Retention. A small response rate to the surveys.

-- “UR (Undergraduate Research), experiences provide academic challenge, an enriching educational experience, active and collaborative learning, and close student-faculty interactions.” (p. 1)

-- “Overall, UR leads to increased student engagement and closer connections to faculty, to other student researchers, and to the institution itself.” (p. 2)

-- “After the conclusion of

The article offers the author's view on undergraduate research in humanities. He mentions the donation of Soviet Union posters dated in the 1920 and 1930s to Willamette University in Salem, Oregon which are considered works of art and propaganda utilized for expressing health, educational and political messages to Russians. He also notes that the


More of a “how not to do it”, lesson in student / faculty research programs.

-- “In our early meetings, the students and I established timetables and deadlines for various tasks, identifying different stages and expectations in carrying out the essay writing and translating. “ (p. 3)

-- “What is manifestly clear to me about this experience is the productive link that connects the tasks of the research with their faculty mentor indicated that they appreciated this unusual opportunity for undergraduates and that this intensified their effort and investment in their own learning. Their responses implied that participation in the program had a significant impact on them; they used words such as enlightening, empowering, and transformational to describe the impact.” (p. 4)
<table>
<thead>
<tr>
<th>Contribution developed into efforts towards student engagement.</th>
<th>Identifying research products and learning outcomes to those of articulating the research proposal, making a persuasive request for financial support, proposing the project to student participants, and framing the project’s design and execution. “ (p. 5)</th>
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<tr>
<td>This article describes the faculty-sponsored approach to undergraduate research (UGR) at Indiana University Purdue University Indianapolis. In this approach, individual or small groups of faculty organize or sponsor the research and recruit undergraduate students to get involved. This approach to UGR is opportunistic in that university faculty members take advantage of the resources and support available on campus to recruit and compensate students.</td>
<td>-- “research provides an opportunity for students to challenge themselves, build relationships with faculty, and add depth to their university experience.” (p. 3)</td>
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<td><a href="http://www.tandfonline.com/doi/full/10.1080/07303084.2013.838111">http://www.tandfonline.com/doi/full/10.1080/07303084.2013.838111</a></td>
<td>-- “The faculty-sponsored approach works well because it allows PETE faculty to engage in the very important activity of UGR that allows undergraduate students to work with a mentor, but in a way that does not add credit hours to an already saturated curriculum.” (p. 3)</td>
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undergraduate students to assist them with the research projects they are conducting for their own line of inquiry.

-- “Once a student has completed the necessary IRB training, faculty start the process of formal mentoring by “hiring” the student. This, along with mutually agreed-upon expectations at the outset of the project and a stipend earned by the student from internal and external grant funds, helps to motivate students through completion of the experience.” (p. 4)

-- “Expectations are then identified as to what should be accomplished by the next meeting.” (p. 4)

-- “Next, the process of developing a product to disseminate begins.” (p. 4)

-- “This progression is where the benefit of the faculty-sponsored format reveals itself, as there is no impending “end” to the semester as in the case of course-based
formats. However, this also means the project has the potential for impediment if there is not an impending timeline for a grade to be offered.” (p. 4)

-- “In these interactions, students grew significantly. These relationships had benefits for women, racial and ethnic minorities, and first-generation college students. The benefits also included increases in retention and continuing education among the aforementioned groups. With this in mind, faculty should be aware that students who work on UGR projects may see mentors as both a professor and a person vested in their personal success.” (p. 4)

-- “Not surprising, STEM related subjects have notable funding available for research and thus UGR programming. This reality
has required PETE faculty to be proactive in finding projects that particularly stress an inquiry-based focus, an identifiable characteristic of STEM-based research.” (p. 5)

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“The reality is that when students self-select a UGR opportunity, it usually means they have an interest in the project (or at least the process) and are willing to do what it takes to get the most benefit out of the project. This fosters a mutually motivating experience that the student and faculty both benefit from.” (p. 5)

| --- | -- These studies generally refer to three main, yet intertwined, challenges to faculty participation: student preparation, time constraints, and demands related to the promotion and tenure process” (p. 20) | -- “Faculty members |
opportunities for students. Based on focus group data from 50 faculty mentors, we document faculty perceptions of the challenges to infusing undergraduate student scholarship across the curriculum. We conclude with practical suggestions for other institutions seeking to implement innovative change initiatives in general and to broaden opportunities for undergraduate research and creative activities in particular.

Immediately identified a list of reasons why they work independently with undergraduates: joy in watching students become part of the discovery process, pride in the work their students produce, and an obligation to provide scholarly opportunities to students.” (p. 23)

-- “Including someone in an existing research project is a risky endeavor and, without proof of skill acquisition, one that many faculty members are hesitant to explore.” (p. 23)

-- “Without basic skills in place, faculty members reported finding it difficult to work either individually with students or to bring them into their research teams. As a result, greater attention is being paid to informal apprenticeships as a way for students to gain access to undergraduate research
opportunities before their senior year.” (p. 23)

-- “They mentioned that students who wait until their final year to engage in student scholarship are sometimes trying to “check a box”, that they are not interested in the scholarly endeavor of research, but are instead trying to secure some competitive advantage during the graduate and professional school admissions process.” (p. 24)

-- “Unfortunately, students who have financial constraints and must work are frequently not able to put the time needed into the labs in order to be prepared to perform their own research or contribute in a meaningful way to existing research projects. Therefore only certain students, specifically those with alternative means of supporting
themselves, are currently participating and will be able to participate in the future.” (p. 24)

-- “Students need to spend time in the labs in order to learn how to do research before faculty members allow them to perform tasks independently. According to these faculty members, 15 hours per week is the minimum commitment expected of students working in their labs, thus precluding undergraduates who work full- or even part-time while completing their course work from participation in student scholarship in these disciplines.” (p. 24)

-- “A one-size-fits-all approach to increasing faculty participation in mentoring undergraduates is going to fail. Student scholarship is by its nature a disciplinary endeavor. Therefore,
there will and should be disciplinary variation in the mechanisms, methods, and approaches to facilitating and evaluating student scholarship.” (p. 28)

-- “Institutions must create incentives and rewards for both faculty members and students to participate in scholarly endeavors with one another. This can include institutional-level recognition of faculty members and students”. (p. 28)

-- “Institutions need to highlight success stories and find ways to ensure that successful partnerships, including those outside of the formal undergraduate research programs, are promoted.” (p. 28)

-- “Opportunities for faculty members and early-career students to be exposed to one
another must be increased. Faculty members could rotate teaching large introductory sections with graduate students leading discussion groups, allowing as many faculty members as desire it the chance to teach and possibly recruit new independent scholars.” (p. 29)

Scientific writing and research methods courses should be encouraged earlier in student tenure.” (p. 29)

|---|---|
| The article focuses on undergraduate student-faculty collaborative research opportunities. Collaborative research fulfills some of the most fundamental educational objectives like personalized education, engaged pedagogy, promoting students' intellectual independence and maturation. Undergraduate research | [http://ezproxy.uvu.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=aph&AN=19405299&site=eds-live](http://ezproxy.uvu.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=aph&AN=19405299&site=eds-live) | Is more of a commentary on UR. Reads more like a Trade Article. | “The curriculum is the purview of the faculty and should be a direct expression of what faculty value in education. It is also one of the ways that faculty gain some control over time, which many regularly cite as their primary limiting resource. Balancing a scholarly agenda with heavy teaching commitments easily consumes available
Experiences is one of the ways through which students build personal connections with faculty mentors. These relationships between students and faculty are very important because this is the time when undergraduates are seemingly mere disengaged in their education and rarely interact with faculty members outside of the classroom. The efforts have been made to design curricula that incorporate discovery-based and active learning which are a must for the independence required for a successful research experience. Many institutes, after recognizing the impact of undergraduate research on student learning, student and faculty retention and institutional reputation, have shown tremendous faith in it.

Time, but utilizing the curriculum to better prepare undergraduates for independent research serves them well and prepares them to contribute to faculty members’ own scholarly work.” (p. 4)

“In this emerging model of effective goals for collaborative research with undergraduates, an ideal project should promote student learning outcomes, advance the research agenda of the faculty mentor, and make a new contribution to the field.” (p. 5)

“Recognizing the impact of undergraduate research on student learning, student and faculty retention, and institutional reputation has led many institutions to respond with extraordinary support for undergraduate research. Colleges and universities have allocated and
sometimes raised funds for student (and faculty) stipends, provided sabbatical leave programs to ensure continued scholarly development for faculty members, reduced teaching loads, rewarded research mentoring activities with teaching credit, provided generous start-up packages for new faculty members, matched funds from external grants, and increased technical support for routine departmental tasks.” (p. 5)

-- ‘Faculty members who teach at primarily undergraduate institutions wonder if the increased emphasis on research and the potential for increased external funding may lead to a decreased emphasis on teaching and time spent with students in out-of-class activities” (p. 6)
"Some consider broad participation of both students and faculty as a primary indicator of a strong program. Others consider this to be the starting point and assess quality in terms of the numbers of students going on to do graduate work in the discipline, students co-authoring publications and making presentations, and faculty-raised external grants." (p. 7)

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"Leading Undergraduate Research Organizations:
- The Council on Undergraduate Research and its affiliated colleges, universities, and individuals share a focus on providing undergraduate research opportunities for faculty and students at predominantly undergraduate institutions. [www.cur.org](http://www.cur.org)
- Project Kaleidoscope is an informal national alliance working to build..."

Many economics majors write a senior thesis. Although this experience can be the pinnacle of their education, publication is not the common standard for undergraduates. The authors describe four approaches that have allowed students to get their work published: (1) [http://ezproxy.uvu.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=eoh&AN=1125749&site=eds-live](http://ezproxy.uvu.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=eoh&AN=1125749&site=eds-live)

The results do not yield a sufficient number of cases to conduct a rigorous analysis. Student success is perceived as a published paper, not what the student has learnt in the process.

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“Even the best students need frequent contact with their advisor and constant mentoring to ensure that the project is making a genuine contribution. (p. 13)"

“We suggest seeking students with raw ability and self-discipline rather than existing skills: strong learning environments for undergraduate students in mathematics, engineering, and the various fields of science, with an emphasis on what works. [www.pkal.org](http://www.pkal.org)

- The National Conference on Undergraduate Research promotes undergraduate research scholarship and creative activity done in partnership with faculty or other mentors as a vital component of higher education. [www.ncur.org](http://www.ncur.org)
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<th>Identify a topic, such as competitive balance in sports, and have students work on various subtopics, such as specific sports; (2) develop a large data set and have students work on different problems using it; (3) divide a quantitative problem into distinct parts and have individual students work on each part; and (4) divide a qualitative problem into distinct parts and have individual students work on their own part. The authors also address the challenges of working with undergraduates: limited time and resources, limited skills, and the tedium of gathering data.</th>
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<tr>
<td>Although skills can be taught, the ability to learn and to self-direct is much harder to instill.” (p. 14)</td>
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<td>-- “Encourage questions and feedback, both so that you can stay alert to potential problems and so that your students get in the habit of evaluating their own knowledge and testing it against others.” (p. 14)</td>
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<td>-- “We believe it also can be very helpful to integrate the research of your students into your courses when appropriate.” (p. 14)</td>
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<tr>
<td>-- “We have found that nothing motivates good students more than the idea of being a full partner on a research project.” (p. 14)</td>
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<td>Although we have focused on our successes, the individual approaches that we have described also have produced</td>
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disappointments. Student projects that we had hoped might lead to publication have been abandoned due to...

1. The project requires more work than the student, or perhaps the professor, is willing or able to undertake.
2. Not appreciating how much supervision is necessary to make a research project successful. As previously noted, a common theme across our experiences is that undergraduates will require much supervision to produce high quality research.


This chapter delineates the consortial activities of the Council of Public Liberal Arts Colleges (COPLAC) to explore models of undergraduate research and to address the impact of undergraduate research on faculty workload. The significant progress made on the member campus of


The article only discusses the barriers to increased faculty Involvement in UR.

--- “Unless there are formal procedures for rewarding UR in promotion, tenure, and renewal or strong evidence that faculty benefit in the form of increased scholarly productivity from mentoring, some form of compensation will be necessary for continued faculty involvement.”
the University of Wisconsin-Superior over the last 10 years is highlighted as an example of the fortuitous impact of several concurrent factors in advancing undergraduate research.

enthusiasm for this work.” (p. 5)

Having students complete UR during the summer on a noncredit (with no tuition or fees) basis reduces any concern with fitting it into the required curriculum, but, with no tuition revenue, funding to compensate faculty must be obtained from other sources.

-- “Having students complete UR during the summer on a noncredit (with no tuition or fees) basis reduces any concern with fitting it into the required curriculum, but, with no tuition revenue, funding to compensate faculty must be obtained from other sources.” (p. 6)

-- “Participating in an unpaid summer UR experience would be difficult for many of these students who are likely to need some income from the summer to pay for
tution and other college expenses. Paying tuition for a credit-generating experience would be even more difficult. Even if year-round Pell grants are restored, obtaining external funds to provide student stipends as well as to compensate faculty will be a challenge and a reason this approach will not support a broad UR program on many campuses.” (p, 6)

| 9. Gallagher, C. T., Mcdonald, L. J., & Mccormack, N. P. (2014). Undergraduate research involving human subjects should not be granted ethical approval unless it is likely to be of publishable quality. *HEC Forum*, 26(2), 169-180. doi:http://dx.doi.org/10.1 | Small-scale research projects involving human subjects have been identified as being effective in developing critical appraisal skills in undergraduate students. In deciding whether to grant ethical approval to such projects, university research ethics ProQuest document link Study is limited to Students of medicine, dentistry and pharmacy. Its does not review the impact of of UR. | -- “Not surprisingly, barriers to more engagement in these activities were identified as “time” and “money.” (p. 8) -- “Typical learning outcomes for student research projects might include: using and evaluating research methods and designs; employing and evaluating appropriate methods for analysing data; critically interpreting information within the context of existing data; and drawing

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committees must weigh the benefits of the research against the risk of harm or discomfort to the participants. As the learning objectives associated with student research can be met without the need for human subjects, the benefit associated with training new healthcare professionals cannot, in itself, justify such risks. The outputs of research must be shared with the wider scientific community if it is to influence future practice. Our survey of 19 UK universities indicates that undergraduate dissertations associated with the disciplines of medicine, dentistry and pharmacy are not routinely retained in their library catalogues, thus closing a major avenue to the dissemination of their findings. If such research is unlikely to be published in a peer-reviewed conclusions so as to propose possible avenues for future study.” (p. 8)
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<td>The American Physical Society recently released a statement calling on all university physics departments to provide or facilitate access to research experiences for all undergraduate students. In response, we investigated the current status of access to undergraduate research at University of Colorado Boulder (CU), a large research institution where the number of</td>
</tr>
<tr>
<td>Article does not focus on the Impact of UR, rather, it puts forward ideas on how to provide UREs to more students.</td>
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<td>-- “Undergraduate research experiences (UREs) have many benefits for students and faculty members. Student benefits include improved technical skills, a deeper understanding of the nature of science, and a stronger sense of identity as a scientist.” (p. 1)</td>
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<td>-- “This rate of undergraduate engagement in research is partially due to an</td>
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undergraduate physics majors outnumber faculty by roughly ten to one. We created and administered two surveys within CU's Physics Department: one probed undergraduate students' familiarity with, and participation in research; the other probed faculty members' experiences as research mentors to undergraduates. We describe the development of these instruments, our results, and our corresponding evidence-based recommendations for improving local access to undergraduate research experiences. Reflecting on our work, we make several connections to an institutional change framework and note how other universities and colleges might adapt our process.

infrastructural constraint: in a department with about 500 majors, the student-to-faculty ratio is 10:1, making it difficult to provide on-campus UREs to all students.” (p. 1)

-- “One strategy for improving access to UREs involves connecting students to off-campus research experiences.” (p. 1)

-- Areas of improvement raised in this study.
“Raise awareness of research-related programs, research groups, and local national labs among majors.
“Raise awareness of the practices of undergraduate research.”
“Raise awareness about pathways to UREs through official and centralized communication channels”
“Raise awareness and promote positive student perceptions about UREs as early in their undergraduate career as
- "In response to the areas of improvement which emerged from the survey data, we crafted five recommendations for improving students access to UREs in the CU Physics Department: (1) create a “Frequently-Asked-Questions (FAQ) About UREs” page on the department’s website, (2) host a symposium on access to UREs each fall, (3) host a poster session for UREs each spring, (4) develop a sophomore-level Research Methods course, and (5) explore partnerships with local national labs to create opportunities for off-campus UREs.”


Undergraduate research is defined by the Council on Undergraduate Research (CUR) as “an inquiry or investigation conducted by an undergraduate student that makes an original intellectual or


The article explores the role libraries can play in UR and where there is room for improvements. It does not discuss best practices for UR or its impact on student retention.

-- “There is a growing body of evidence indicating that scholarly disengagement can be reversed when students participate in high-quality, discipline-oriented undergraduate research
creative contribution to the discipline.” This study serves as a snapshot of current library practices in relation to formal undergraduate research programs and identifies common elements of library support among different types of institutions. The results of this research fill a gap in both the library and education literature, provide critical background data for libraries wishing to build support for undergraduate research programs, and suggest a foundation for further research into an underexplored area.

-- Examples of programs (UREs) include:
- Formal undergraduate research opportunities program.
- Undergraduate research symposia that highlight original and creative undergraduate work.
- Undergraduate research journals that publish original undergraduate research.
- Undergraduate honors programs.
- Other formal initiatives that foster original undergraduate research or creative works.

-- “Undergraduate participation in such programs aligns with gains in a host of educational outcomes, and it is well established in the higher education literature that undergraduate research programs are a valued and viable method of improving students’ academic experience.” (p. 1)
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<td>As a means of promoting scholarship, faculty are increasingly including undergraduate nursing students as team members in faculty-led research projects. Research involvement is a high-impact educational practice that enhances student engagement and retention rates and enables the reflection and integration of learning. The purpose of this article is to describe the benefits and innovative ways of directly involving undergraduate nursing students in faculty-guided research projects. Case examples from four non-research-intensive nursing programs are presented to illustrate the benefits of undergraduate student research involvement to students, faculty, their communities, as well as the nursing profession. Student assistance in all phases of the research</td>
<td><a href="http://ezproxy.uvu.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&amp;db=aph&amp;AN=109379257&amp;site=eds-live">http://ezproxy.uvu.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&amp;db=aph&amp;AN=109379257&amp;site=eds-live</a></td>
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<td>Study is limited to Nursing Students only.</td>
<td>2) “The case examples show that student-faculty scholarship is particularly exciting and productive when it is designed to extend beyond using students to simply help collect data.” (p. 1354)</td>
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<td>“One of the key elements of a high-impact practice, such as engaging students in research, is that there be “frequent, timely, and constructive feedback” (p. 1354)</td>
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| | | “Some of the case examples pertain to research projects that are ongoing over the course of several semesters, allowing students to see the process of scholarship unfold over time and enabling multiple students to participate in these opportunities. With student teams passing the research projects on from one semester to the next, a potentially very small-
process, ranging from research question generation, literature reviews, methods development, and data collection and analysis, to presentations and manuscript publication, motivates and helps faculty progress with their research programs. Benefits also include the creation of effective learning experiences that build nursing knowledge and potentially contribute to community health scale study is able to grow in size with multiple data points or increased participant numbers.” (p. 1354 & 1355)

| 13. Louis, R. (2008). Collaboration at the crossroads: A community-based arts research initiative. *Council On Undergraduate Research Quarterly, 29*(2), 22-25. Retrieved from Education Full Text | The writer describes a community-based arts research initiative. Specifically, he looks at a research collaboration at Xavier University of Louisiana involving an undergraduate student and a faculty member, a public high school, and a community arts program. He describes the institutional infrastructure that facilitated the initiative, community-based research, and | http://ezproxy.uvu.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=eft&AN=508026051 | The study refers to the experiences of one student and faculty member only. -- “In my case, I gained a new appreciation for how undergraduate research facilitates student and faculty co-learning, which can itself signify a project’s value.” (p. 24) -- “Undergraduate research can produce knowledge and reciprocity. Students and faculty members can contribute scholarship to their disciplines, engage in collaborations that
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<th>Lessons learned from the negotiation of scholar, research mentor, and community partner roles. Thus, he illustrates a model for undergraduate research that promotes scholarly reciprocity, student learning, and civic engagement.</th>
<th><a href="http://ezproxy.uvu.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1041422&amp;site=eds-live">http://ezproxy.uvu.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1041422&amp;site=eds-live</a></th>
<th>Describes, but does not measure the success of the ‘ORDER’ Liberal Arts Education / Undergraduate Research approach to learning on Student success or retention.</th>
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<tr>
<td>In this nascent age of massive online education, it is important to recognize that the goals and successes of a liberal arts education have been to provide an intellectual array of ideas that build critical thinking skills and to engage a new generation of students with society’s great challenges and vast opportunities. Nowhere are these opportunities richer than in the basic research questions being posed every day at a research university. In this paper, we argue that the goals of a liberal arts education and</td>
<td>14. Kaiser, B. N., Mishler, D. M., Peoples, W. A., &amp; Wells, A. S. (2014). Undergraduate research and a liberal arts education: Similar goals, similar solutions. <em>Journal of College Science Teaching, 43</em>(5), 48-54. Retrieved from ERIC</td>
<td>“ORDER initiates freshmen and seniors into the research process through a module-based course with a multidisciplinary group of students and instructors. Each module presents the research of one teacher—scholar who uses his or her project to introduce broader questions, epistemologies, and methods of their discipline. (p. 2)</td>
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<td>describe, but does not measure the success of the ‘ORDER’ Liberal Arts Education / Undergraduate Research approach to learning on Student success or retention.</td>
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"For instance, in a module on religious history, students engaged the instructor’s primary source documents and artifacts. They developed..." (p. 25)
undergraduate research are remarkably similar and that by incorporating an undergraduate research focus with a liberal arts approach in the classroom, instructors can more effectively achieve the goals of both. We present the example of ORDER (On Recent Discoveries by Emory Researchers), a series of multidisciplinary, team-taught seminar courses for freshmen and seniors. We argue that ORDER’s unique structure provides students with effective opportunities to achieve the core goals of a liberal arts education and a research education, namely to enhance the ability to think critically and draw connections, engage in research as a process, pursue authentic investigation of real-world problems, develop interdisciplinary and collaborative skills, and present ideas creatively.

questions regarding the origins and intent of these materials and constructed a plan for addressing their questions. The exercise required students to critically engage not only the module’s historical content, but also the methodological approaches that shape historical research.” (p. 2)

-- “One freshman student said, “ORDER has clearly geared my interests towards research. With my exposure to the ORDER fellows’ own individual research projects, my own scope of what research meant expanded.” (p. 3)

-- “The multidisciplinary nature of ORDER brings about four major changes to teachers’ experience: (a) it allows instructors to disseminate their research to a wider audience than traditional classroom structures allow, (b) it encourages the
exploration of collaborative teaching, (c) it requires teacher–scholars to reconsider their relationship to their own field of research in light of exposure to new avenues of thought, and (d) it invites instructors to incorporate multiple pedagogical styles. These changes also affect student experiences, as instructor and student navigate the evolving terrain of interdisciplinary and collaborative research together. (p. 4)

-- “As evidenced by this ambitious group, the ORDER experience empowered students to conduct independent research and take ownership of their own education, inside and outside the classroom,” (p. 4)

-- “Students critically engage course content, develop research questions, design
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<td>The article focuses on the importance of integrating undergraduate research in teacher education in the U.S. Topics include the benefits of undergraduate research to students such as refining their teaching skills, developing an appreciation for research, and broadening their knowledge of discipline, the barriers facing faculty and students, and the need to have more Council on Undergraduate Research (CUR) institutes and workshops to help engage education students in undergraduate research.</td>
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<td>Discussion is limited to Students in Teacher Education.</td>
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<td>-- “Faculty and students across the country have suggested several barriers to undergraduate research in teacher education. Faculty members often cite a lack of time as a reason they are unlikely to mentor undergraduate researchers.” (p. 1)</td>
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<td>-- “Faculty members also suggest that mentoring an undergraduate researcher may take away time from their own research and scholarship.” (p. 1)</td>
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<td>-- “Education students similarly cite their demanding course load and pre-practicum/practicum experiences as making them hesitant to seek out research experiences.” (p. 2)</td>
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These models of undergraduate research—which already often occur in teacher-education programs—include action research, analysis of archival research, classroom observations informed by a literature review, case studies of particular K-12 students, and curriculum-unit and lesson design (Shanahan 2012). “ (p. 2)

- " When reflecting on their undergraduate research experiences, education students often say that it has provided them with a more comprehensive understanding of the field of education and that it has influenced their future teaching career.” (p. 3)

-- “It is certainly clear that conducting undergraduate research in education intellectually engaged these students, fostered a deeper understanding and
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<td>INTRODUCTION</td>
<td>Institutional repositories provide an opportunity to enhance the undergraduate education experience by developing student-centric collections. This article highlights five IR collections focusing on undergraduate student work at a medium size university. LITERATURE REVIEW Students benefit when they actively participate in undergraduate research activities that are tied to high-impact educational practices. However, there are limited options for undergraduate students to publish and share their work. Academic librarians are well-positioned to develop a student-centric institutional repository supporting undergraduate student research while working at instilling better...</td>
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<td><a href="http://ezproxy.uvu.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&amp;db=aph&amp;AN=97431233&amp;site=eds-live">http://ezproxy.uvu.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&amp;db=aph&amp;AN=97431233&amp;site=eds-live</a></td>
<td>Does not discuss the benefits of UR, rather how a particular institution has created a platform for publishing the UR.</td>
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<td>-- Referring to Undergraduate Peer-reviewed research journals... “These student collections have the ability to increase student academic confidence, provide access to student research and scholarship, introduce scholarly communication concepts and practice, offer internal and external promotion of programs, provide inclusive opportunities and documentation of student scholarship, and contribute to student retention.” (p. 2)</td>
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<td>-- “The library has grappled with gaining permissions for student work, but not from the audience anticipated. Students have been easy to work with and grasp what it means to make their work available online. The challenge...</td>
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information literacy standards and practices. DESCRIPTION OF PROJECT Western Oregon University’s Hamersly Library developed an institutional repository with an initial collection development strategy around undergraduate student collections based on the university’s strong identity and emphasis on undergraduate education. While traditional academic publishing opportunities are represented, there is also space and encouragement for publication of other types of student created material including presentations and creative works. There is an emphasis on representing student work from all grade levels. By connecting the student scholarship collections to high-impact educational practices, the library can advocate and demonstrate additional comes from the faculty, who has expressed concerns over posting student work for two main reasons: plagiarism and quality of work.” (p. 9)
types of value that resonate with faculty and university administrators. NEXT STEPS The library will explore student publishing opportunities that originate in existing classes and new courses taught by librarians. Library faculty will continue to educate university administration and faculty on scholarly communication initiatives and their concerns of plagiarism and quality of work.


A report on a conference on challenges of and prospects for undergraduate research in the humanities, which was held at Hendrix College, Arkansas, in September 2007. The report outlines major ideas that emerged from the conference and indicates the promise of collaborative research with students in the humanities.


Limited to the experiences of Humanities students and faculty only. No research was conducted, rather the piece attempts to capture some of the major ideas that emerged from two days of intensive discussion and debate at a weekend conference titled "Undergraduate Research in the Humanities: Challenges and Prospects."

“Participants at our conference observed that institutions—especially those dedicated to the pursuit of the liberal arts—need to create administrative structures that recognize and reward faculty members who take on humanities students for shared research and writing projects.” (p. 26)

“In short, there may be no innate reason, aside from the weight of
encrusted tradition, why research in the humanities needs to be less collaborative than research in other disciplinary areas. Humanities scholars need to process, share, and work to create the kinds of bureaucratic models that will promote research communities.”
(p. 27)

-- “The hurdle to jump here may be the assumption by many of us in the humanities (me included) that authentic research must be original research in order for it to be meaningful. This is essentially a paradigm for student research that we have inherited from graduate and professional schools, shaping how we think of doing work with our undergraduates.”
(p. 27)

-- “We academics, as one of our conference participants put the
matter, may have a strong desire to replicate ourselves in the lives of our students. There is an ethical and moral dilemma here that goes, for the most part, unobserved in discussions of undergraduate research. The desire to perpetuate the academic species may be well intentioned, but it narrows our angle of vision when it comes to seeing undergraduates as fully vested research partners.” (p. 28)

-- “Let’s think our way out of this corner. If we were to focus on the process of undergraduate research rather than its outcomes (narrowly defined), might we not glimpse its value more clearly?” (p. 28)

-- “For the sake of our students and ourselves, we might consider reframing the proper ends for undergraduate research as encompassing the notion that decent,
strong, even thought-provoking projects may well be derivative and limited so long as they set themselves to the fundamental pedagogical task of "making meaning." (p. 28)

-- “Finally, we need to recognize that as we forge ahead into humanities research with our students, failure is a possible outcome. And that can even be good news... Despite their best efforts, the project collapsed of its own weight. No measurable student learning outcome could be found. To the surprise of some of us on the faculty, however, the students claimed that this experience—this failure—was the most important and most positive academic endeavor of their collegiate careers.

| 18. Stamatoplos, A. (2009). The role of Mentored undergraduate research is an emergent | http://ezproxy.uvu.edu/login?url=http://search.ebsc | Examines the role Libraries can play in UR | -- “Because it is an experiential form of |
| Pedagogy in higher education. It differs fundamentally from course-related student research and is largely independent of the curriculum. Academic libraries should engage formally with the undergraduate research community. To do so, librarians will need to think and work beyond traditional models of library service, most notably in information literacy programs. The intent of this article is to raise awareness about opportunities for library involvement with undergraduate researchers and programs. Lessons from one university, including a formal partnership between a library and an undergraduate research center, suggest some general strategies that academic libraries might explore. | ohost.com/login.aspx?direct=true&db=lxh&AN=40507819&site=eds-live | learning, campuses are recognizing undergraduate research as an important recruitment and retention tool.” (p. 235) -- “Undergraduate research engages the student in inquiry-based and experiential learning. Students learn through practicing the methods of the discipline.” (p. 237) -- “Faculty mentors guide and provide structure to students' research experiences. Student researchers are treated as members of the scholarly community, even if they are still novice members.” (p. 237) -- “Students have primary responsibility for their projects, or some portion' of them, and they take ownership of their work. Mentors encourage researchers to think and work independently,
though they may collaborate on team projects with other students and faculty.” (p. 237)

-- “Research is informed by, and builds upon, previous scholarship. Students become familiar with and appropriately use the literature of the disciplines and topics.” (p. 237)

-- “Information literacy seems to be either assumed or ignored. Ironically, students engaged in such activities may have greater and more complex overall need for quality information and evaluative skills than the average student engaged in course-related activities.” (p. 239)

-- “Because librarians interact with students in developing transferable skills, knowledge,
attitudes, and strategies when they assist them with their research, they affect student performance positively in other areas of their education.” (p. 240)

-- “Early in the library-UROP collaboration, there was a realization that students commonly think about and approach independent research differently from the way they think about and approach course-related research. Undergraduate researchers often had closer contact with faculty members in the mentoring environment than in the classroom environment, and their information use appeared to rely more on their mentors' ideas, suggestions, and sources. Though not as practiced as their mentors, undergraduate
researchers seemed to seek and use information in ways similar to seasoned professional researchers.” (p. 242)

-- Some recommended strategies for Librarian engagement in Undergraduate research:
1. Develop appropriate awareness and understanding.
2. Identify and create opportunities.
3. Focus on enhancing Student / Mentor Relationships.
4. Develop new frameworks for working with Students and Faculty.
5. Make strong and explicit commitments to Undergraduate Research programs. (p. 244 & 245)

-- “Undergraduate research presents opportunities for librarians to extend their reach on campus and engage a larger number and broader range of
students, faculty, and disciplines. This requires collaborative relationships in which librarians are partners with faculty and students. In such collaboration, librarians must be open to new and creative strategies for contributing to education and scholarship. The result should be not only greater involvement but also greater impact in the academic community.” (p. 246)


Describes the collaboration of the authors, an assistant professor and an undergraduate student, in creating an online teaching module dealing with events in 1968 for ‘The Digital History Reader’ project funded by the National Endowment for the Humanities. The authors consider their


Study is limited to the experiences of one faculty member and one student only.

--- “We want to stress that what made this project successful for both of us was the sense of collaborating on a joint enterprise, rather than a faculty member merely using an undergraduate for research assistance.” (p. 535)

--- “Lecturing to students two or three times a week
collaboration a success but note such obstacles as traditional university teaching methodology, skepticism from students, and the amount of work required for the project. 

no longer offers an efficient and effective means of promoting learning. (p. 538) 

--- “Indeed, one of the most significant lessons from our experience is that the incentive of creating a product that would have an afterlife made for effective student learning.” (p. 538) 

--- “Even if there is impetus for reform along the lines of undergraduate research, we see no possibility that undergraduate education will become dominated by individualized instruction. If only for financial reasons, it will not happen.” (p. 539) 

--- “it is also fair to ask, as liberal education is increasingly replaced by job training at research universities, whether, given the opportunity to engage in collaborative
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<td>Undergraduate research (UR) is a valued co-curricular activity that has involved an increasing number of students and faculty members in recent years. While there is a growing body of research on student participation in UR, there is less research available examining faculty perceptions of, participation in UR, and how those factors influence student participation in UR. This study examined approximately 110,000 responses to the National Survey of Student Engagement and 40,000 responses to the Faculty Survey of Student Engagement at over 450 four-year institutions.</td>
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<td>Data reported herein were captured from self-report surveys. Respondents could have indicated higher use or value of UR than what actually occurred.</td>
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<td>-- “Regarding personal characteristics, full-time students, students of color (particularly African American students), and students less than age 24 were more likely than their peers to participate in UR.” (p. 11)</td>
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<td>-- “Full and associate professors were much more likely to participate, particularly when compared to their non-tenure-track colleagues.” (p. 11)</td>
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<td>-- “The importance that faculty members place on UR is positively related to the proportion of students who participate in UR, even after controlling for faculty time spent on UR research, many undergraduate history majors would accept the challenge. We suspect many would decline, choosing to take an “easier” course.” (p. 540)</td>
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Findings revealed that individual and institutional characteristics predicted student and faculty member involvement and that the majority of faculty members perceived UR to be of importance. Implications for fostering faculty involvement, student success, and viewing UR as an institutional asset are discussed.

-- “It is noteworthy that compared to White peers, minority students in this study report higher participation in UR, as do men, those who live on campus, and those who do not enroll in online education courses.” (p. 14)

-- “Women and first generation students report lower participation in UR than male and peers who are not of first generation to attend college. While the coefficients indicate a small finding, the result is statistically significant and thus urges us to point out the need to invest even greater attention to women and underrepresented students in UR.” (p. 16)

-- “If faculty believe their work will be enhanced through UR, they may be...
more likely to participate. Faculty member perception of enhancement may be achieved in one of several ways—through student assistance on research projects that lighten the faculty member’s time, through feelings of satisfaction in serving as a mentor to help students learn, and/or in feeling satisfaction in helping to achieve the institution’s goals related to student graduation and preparation for graduate school.” (p. 16)

-- “Institutional expenditures can make a difference in positive outcomes, and believe our findings reaffirm the need for institution officials to continue allocation of resources for in-class and co-curricular discovery-based learning activities.” (p. 18)

-- “engagement requires a broad-based commitment
By partnering in the publication of undergraduate journals, libraries can further establish a connection with students and faculty, supporting the notion that culture matters. It might also signal that involvement with students in undergraduate research (UR) is personally rewarding for faculty mentors and can be beneficial in the completion of research tasks. (p. 18)

The article focuses more on the success of the JPUR publication than the impact of the Student UR. The student article authors could select multiple reasons when asked why they decided to write an article for JPUR. The most frequently cited reason was to be more successful in their undergraduate student success. Academic activities that assist in underwriting student success may encourage students to consider graduate education. (p. 18)

The article examines what students learn from participation in an undergraduate research journal. Results of an assessment. (p. 18)


By partnering in the publication of undergraduate journals, libraries can further establish a connection with students and faculty, supporting the notion that culture matters. It might also signal that involvement with students in undergraduate research (UR) is personally rewarding for faculty mentors and can be beneficial in the completion of research tasks. (p. 18)

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between library publishing and student success. This paper reports on an assessment of the Journal of Purdue Undergraduate Research (JPUR) that was designed to evaluate student learning outcomes and demonstrate connections between journal participation and student success. METHODS The assessment plan included all student and faculty stakeholder groups. Online surveys were distributed to primary stakeholder groups annually for three years; students who attended workshops were asked to complete evaluations; and web metrics were collected. RESULTS The findings indicated that students experienced gains in learning as a result of writing an article, writing a research snapshot, or mentoring a student author. Because of their involvement with competitive as a graduate school applicant.” (p. 9)

-- “Since writing a paper for publication involves many distinct information literacy competencies, JPUR directly addresses several important areas for student learning (e.g., how to synthesize information, how to use evidence to draw conclusions, how to evaluate the credibility of authors, how to properly cite others' work, et al.).” (p. 13)

-- “While it is easy to state that student learning is the goal for an undergraduate journal, it is important to have a well-planned assessment strategy that can confirm that the journal is actually accomplishing this purpose.” (p. 14)
JPUR, student authors intended to publish articles in the future. JPUR influenced career decisions. Faculty were motivated to continue to act as mentors for undergraduate research.

DISCUSSION & CONCLUSION The assessment showed that student authors benefitted from experiencing the full spectrum of the scholarly publishing process. Notably, students gained knowledge of important information literacy concepts. These learning gains and the demonstrated influence of JPUR on student career and scholarly aspirations clearly show that publication of an undergraduate research journal supports university priorities for student success as well as the Libraries' strategic priorities of information literacy and scholarly
communication. It is recommended that other institutions that are publishing undergraduate journals undertake similar assessments, which will further establish the value of such publications.


| A collaborative research grant from the National Science Foundation allowed the first two authors to provide students at primarily undergraduate institutions with a multi-faculty, multi-institution team research experience. Teams of undergraduate students at Western Carolina University and Washington and Lee University collaborated with one another on multiple projects. Research teams used Skype and Dropbox to facilitate meetings and the sharing of research articles, documents, and data. Through collaboration across institutions, students could benefit from the expertise of multiple faculty members. | [http://top.sagepub.com/content/42/1/60.full.pdf+html](http://top.sagepub.com/content/42/1/60.full.pdf+html) | Small survey group. Only 22 Students. |

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-- “Single-faculty, single-project team, and the multi-faculty, multi-project team. As the names suggest, the single-faculty, single-project model, involves one faculty member supervising a small group or team of undergraduate students as they work together on a single research project. The multi-faculty, multiproject model, consists of two or more faculty members and several students collaborating on multiple projects.” (p. 1)

-- “These results suggest that a multi-faculty, multi-institution team model can uniquely benefit students by providing...
gained a fuller appreciation of research as a dynamic process that involves discussing and critiquing ideas and complementing one another's skills.

"Working in teams on common projects, students learned ways to effectively share information with one another and to truly collaborate within a diverse research community—to share and critique one another's ideas and to rely on and complement one another's skills" (p. 3)

A collaborative research grant from the National Science Foundation allowed the first two authors to provide students at primarily undergraduate institutions with a multi-faculty, multi-institution team research experience. Teams of undergraduate students at Western University.

One limitation of the current research is that students were asked to self-report the impact of their research experience on several types of skills.

-- “These results suggest that a multi-faculty, multi-institution team model can uniquely benefit students by providing them with a broader and more sophisticated understanding of the research process than a single faculty collaborative model.” (p. 62)
Carolina University and Washington and Lee University collaborated with one another on multiple projects. Research teams used Skype and Dropbox to facilitate meetings and the sharing of research articles, documents, and data. Through collaboration across institutions, students gained a fuller appreciation of research as a dynamic process that involves discussing and critiquing ideas and complementing one another's skills.


Undergraduate research experiences provide students with opportunities to engage in high-impact experiential learning. Although prevalent in the sciences, there are now extensive banks of case studies demonstrating the use of undergraduate research as an educationally


Research is limited to one institution only dominated by a large number of schools representing ‘Hard’ disciplines.

-- “Disciplines are categorised as ‘pure’ or ‘applied’ depending on the purpose for which new knowledge is developed, and as ‘hard’ or ‘soft’ depending on the degree of paradigm consensus. For example, mathematics is generally classified as a hard pure discipline, because it is
enriching activity across many disciplines. This study investigated the diversity of undergraduate research opportunities available across a wide range of disciplines at a large, research-intensive, Australian university. Through extensive interviews, 68 undergraduate research programmes across 26 discipline-based schools were characterised. A typology of undergraduate research models is proposed, revealing key characteristics underlying the ways in which research experiences are embedded in undergraduate curricula across a diverse range of disciplinary contexts. This provides guidance to academics, administrators and policymakers seeking to improve student access to undergraduate research experiences.

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<th>Model</th>
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<td>Apprenticeship</td>
<td>Students work under the direct supervision of an academic staff member, in an area related to the academic’s current research or expertise.</td>
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<tr>
<td>Industry project</td>
<td>Students focus on a complex problem they are likely to encounter in their profession.</td>
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concerned primarily with developing knowledge on how and why the universe functions in certain ways (pure), using strict methodological approaches which require a high level of disciplinary expertise to understand (hard).” (p. 3)

-- “We identified four broad models, plus a mixed model category, that reflected the major differences in the characteristics of the undergraduate research activities within our broad database of case studies:
Inquiry project - Students undertake the entire research process with a focus on learning disciplinary content and processes of knowledge production.

Methods course - Students engage in truncated versions of the research process, with a focus on a broad range of methodological processes commonly used in the discipline.

Mixed model - Combines features of two of the above models. “(p. 7)

-- “This categorisation is certainly not offered as a novel typology; rather, the importance lies in our finding that this small collection of models encompassed a diverse range of undergraduate research activities characterised across a broad range of disciplines.” (p. 7)
— “Does the student cohort have an easily identifiable graduate destination industry which can be used to frame an authentic research question?” (p. 13)

— “Is it more important for students to work on a research question that is authentically based on a current problem in research or industry (and thus primarily determined by the academic), or Studies in Higher Education 245 to gain experience in designing their own research question?” (p. 14)

— “In balancing breadth and depth, is it more important for students to gain a broad understanding of a large range of methodological approaches, or to gain an understanding of the complete research process?” (p. 14)
The key characteristics and the descriptions of the models detailed in this article may, therefore, assist administrators and policymakers in each of these nations to identify and promote examples of undergraduate research experiences that already exist in their institutions, and demonstrate their support for integrating appropriate research experiences into the curriculum across a range of disciplinary contexts.” (p. 14)

We have shown that there are also broad differences in the ways in which academics design and implement research experiences in the undergraduate curriculum, with applied disciplines focusing on students using research skills to investigate industry problems, and hard disciplines primarily using models which help
students to understand the complex and stringent paradigms that are the hallmark of their disciplines. However, we have also shown that academics often combine elements of these different models of undergraduate research, and that each type of undergraduate research activity can be embedded into the curriculum of a range of different disciplines. By characterising the models used to embed research experiences into the undergraduate curricula across a broad range of disciplinary contexts, this work has provided a strategic guide for enhancing the diversity of ways undergraduate students can be actively engaged with the research content and processes of their disciplines.” (p. 16)
Peer-Reviewed Articles (Retention and Long-Term Outcomes):

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<th>Citation</th>
<th>Abstract</th>
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<th>Limitations</th>
<th>Conclusions</th>
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<td>1. Fakayode, S. O., Yakubu, M., Adeyeye, O. M., Pollard, D. A., &amp; Mohammed, A. K. (2014). Promoting undergraduate STEM education at a historically black college and university through research experience. <em>Journal of Chemical Education, 91</em>(5), 662–665. doi: 10.1021/ed400482b</td>
<td>Diversification of our country's science talent pool is critically needed and can only be achieved by stimulating interest in science, technology, engineering, and mathematics (STEM) among students from a wide variety of cultural backgrounds. However, motivating, increasing the number, improving retention rates, and graduation rates of underrepresented minority (URM) students in STEM disciplines continue to be a major challenge and of active pedagogical interest to historically black colleges and universities (HBCU). Early involvement of URM students in research is a viable strategy to excite minority students in STEM areas. This work reported the use of the Raising Achievement in</td>
<td><a href="http://ezproxy.uvu.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1032401&amp;site=eds-live">http://ezproxy.uvu.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&amp;db=eric&amp;AN=EJ1032401&amp;site=eds-live</a></td>
<td>Findings are limited to a HBCU Institution.</td>
<td>- &quot;Students who participate in research early, during the first year and second year, are more likely to succeed and graduate with college degrees in STEM disciplines. Such students are also likely to advance to graduate school in STEM areas or proceed to professional schools” (p. 663). -- To support inclusion of students in STEM majors and improve retention Winston Salem State University participated in “Raising Achievements in Mathematics and Science (RAMS) project” (p. 663). -- “Participants were assigned to work for 8—10 h/week with a faculty mentor to conduct research of mutual interest for the academic year. Each scholar received a $2,400 stipend for one academic year but</td>
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Mathematics and Science (RAMS) scholar and Summer Undergraduate Research Experience (SURE) programs at Winston-Salem State University (WSSU) as a strategy for promoting and stimulating the interest of URM students in STEM education at a HBCU institution. The influence of the RAMS scholar and SURE programs on the retention rate and STEM education of the URM students was examined. The experience of RAMS scholars and SURE participants was also evaluated by administering a survey to the participants upon completion of the program. The retention rates of the RAMS scholars and SURE participants were better than that of non-RAMS scholars or non-SURE participants. The analysis of the survey results indicated that the RAMS scholars and SURE participants were assigned to a faculty mentor on a project over a period of 6 weeks. The participants received a $2,400 stipend and room and board for those who needed it. All SURE students must be STEM majors, have a strong interest in attending graduate school, and possess a minimum GPA of 3.00. Along with a small honorarium, limited research supplies and support to attend conferences were also may be renewed for another year. To qualify as a RAMS scholar, the student must be a first year or second-year STEM major and have a GPA of 3.0 or higher. However, first-year students and students with GPA of less than 3.0 who expressed strong interest in research and graduate studies in STEM have also been admitted into the RAMS program.” (p. 663) -- Summer Undergraduate Research Experience (SURE) participants were assigned to a faculty mentor on a project over a period of 6 weeks. The participants received a $2,400 stipend and room and board for those who needed it. All SURE students must be STEM majors, have a strong interest in attending graduate school, and possess a minimum GPA of 3.00. Along with a small honorarium, limited research supplies and support to attend conferences were also
scholar and SURE programs clearly generated URM student excitement, while promoting critical thinking, teamwork, and leadership skills. Moreover, RAMS scholars and SURE participants particularly enjoyed other program enrichment activities, including professional development seminars and social activities as well as poster and oral presentations at regional and national conferences.

provided to the research mentors. Speakers from graduate and professional schools were invited to give seminar presentations on various research topics and also to inform the SURE participants about the admissions process and scholarship opportunities available at their institutions for prospective graduate students. Seminar presentations on laboratory safety, ethical conduct in research, scientific writing, and poster presentation were also provided. Social activities, including, a movie and pizza night and bowling were incorporated into the SURE program to promote social interaction and networking between the SURE student participants and faculty mentors in an informal setting.” (p. 663)

--- “Retention rates for first-year (77.8%), second year (61.9 %), third-year
(56.8%), and fourth-year (35.4%) students were observed at WSSU in 2008. The first year (47.5%) and second-year (34.4%) retention rates were recorded for STEM majors at WSSU in 2007. Similar first year (48.5%) and second-year (29.6%) retention rates were obtained for STEM majors in 2008. In contrast, a high retention rate for RAMS scholars after year 1 of 98.8% was observed. The retention rate of RAMS scholars of 98.8% was maintained after year 2, year 3, and year 4. In fact, less than 1% of the 88 RAMS Scholar program participants dropped out of the program due to GPA, research schedule problems, or change in full-time status.” (p. 663-664) -- “It is of considerable interest to note that the entire 2009 RAMS scholar cohort has graduated in STEM disciplines (with graduation rate of 100%) and are currently enrolled
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<td>In 1996, faculty at Sitting Bull College (SBC, Fort Yates, North Dakota) developed its Environmental Science (ENS) Program, basing it on the scientific method and techniques students would need for employment in environmental technician positions with local and tribal agencies. Over the course of 15 years, this employment-based training evolved into research-based training that also requires all students in the Environmental Science Department to conduct and defend a full research project for graduation. This requirement was not only well received but has led to many unexpected benefits for the program. Research and</td>
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<td>The article discusses UR in a single Tribal College only.</td>
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<td>in either M.S./Ph.D. graduate programs or professional schools.” (p. 664)</td>
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<td>-- “A crucial part of the program allows students the opportunity to conduct individual research -- and that is the primary recruitment and retention tool we use.”</td>
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<td>-- “We quickly realized that offering a variety of research opportunities allowed us to recruit a broader range of students. Providing opportunities during the summer and during regular semesters that are both short term and long term, and are either local or involve traveling to exciting locations, make our program attractive to a wide assortment of traditional and non-traditional students.”</td>
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<tr>
<td>-- “When asked why they chose to stay in school while some other students</td>
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presentations are a core part of the ENS Program and enhance a student's organization, professionalism, and critical thinking skills. SBC currently offers four distinct research programs that provide stipends to allow students the opportunity to conduct individual research projects. These include: (1) Semester Research Courses; (2) Summer Research Experience for Undergraduates (REU); (3) Native Undergraduates Tropical Research Opportunities (NUTRO); and (4) North Dakota Office of Experimental Program to Stimulate Competitive Research's Nurturing American Tribal Undergraduate Research and Education (EPSCoR's NATURE).

-- “We realized that students were not only more interested in core science courses but also in the general education courses that students often fail to see as applicable to their professional interests. Math courses suddenly had meaning: to analyze their data. English courses meant better reports and presentations. And computer science classes allowed students to manage their data and develop high-quality posters and PowerPoint presentations.

- "Because there is a wealth of empirical data showing the benefits of
|---|

Undergraduate research is one of several high impact educational practices used by educational institutions to increase student engagement and success (Kuh, 2008). Many studies on the impact of undergraduate research have surveyed students or faculty on their personal experience and its influence on students' subsequent degrees and employment (Brownell & Swaner, 2010). These studies have documented the ability of high impact educational practices to have the greatest influence on those students who self-identify participating in undergraduate research programs, funding agencies are very supportive of proposals that incorporate authentic student research activities.

The study is is a correlative study that assesses a possible relationship between students’ final grade in an undergraduate research experience (defined as an independent studies course in this paper), students’ GPA before completion of the undergraduate research experience and students’ GPA in the subsequent year. It is important to note that other mitigating factors can and will influence student GPA and final grades in individual courses (e.g., differences in textbooks, instructors, student...)

--- “Our data reveals that the majority of students with lower than average GPA earned relatively high grades in those research courses, hence receiving accrued benefits from the experience.” (p. 4)

--- “Admission to UREs based only on prior GPA thus appears to be counter-productive by denying access to high impact educational experiences from students who would most benefit from it.” (p. 4)

--- “Students’ GPAs in the year the independent studies course is completed are higher..."
as belonging to a minority or disadvantaged group. Few studies, however, have documented the impact on students with lower grades. The privilege of being admitted to an undergraduate research experience (e.g., an independent studies course) is typically reserved for upper-year students who have proven themselves academically. This paper presents correlational data from our campus showing that academically weaker students have a greater increase in academic performance between prior grade point average (GPA) and final grade in an independent studies course than academically stronger students. In addition, student annual GPA data shows that the impact of undergraduate research serves to raise students’ GPAs in the year of an independent studies cohort ability, classrooms, learning technologies, etc.).

relative to students who do not enroll in independent studies but the GPAs of students without independent studies rise to the same level in the subsequent year. Essentially, undergraduate research seems to raise student GPA a year earlier.” (p. 4)

-- “It appears that the impact of UREs on students GPA is not solely due to a high grade in the URE but rather to a general improvement in academic performance across many disciplines.” (p. 4)

-- “Undergraduate research should be made available in earlier years and not only in students’ senior years.” (p. 4)
course. Although the findings are based on data from one small campus, they do raise the question that if undergraduate research has the greatest impact on academically weaker students and accelerates academic maturity, is limiting registration into these courses on the basis of superior GPA and years of study placing inappropriate boundaries on student learning?

| 5. Hoffman, J. R. (2009). Applying a cost-benefit analysis to undergraduate research at a small comprehensive university. *Council on Undergraduate Research Quarterly, 30*(1), 20-24. Retrieved from Education Full Text | The value of supporting undergraduate research at small comprehensive universities is revealed through a holistic review of benefits. Rather than examining only economic costs, comprehensive consideration of both direct and indirect benefits of providing undergraduate research opportunities holds rewards for the university and faculty members and students. Through an undergraduate research | http://ezproxy.uvu.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=eft&AN=508101137&site=eds-live | -- “Despite the difficulty of isolating the main effects of research opportunities from other activities the student is exposed to on campus, the descriptive evidence indicates that undergraduate research programs are a vital component of an integrated retention strategy for STEM students. (p. 22) 

-- “For students entering the job market directly after graduation, a strong
program, a university can meet goals that include recruitment of well-prepared students, enhanced retention, and stronger graduation rates among students traditionally underrepresented in the sciences. Moreover, a quality program can help to enhance the university’s prestige and attract donors.

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<th>undergraduate research experience may substitute for “years of experience.” (p. 22)</th>
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<td>“There are a number of indirect benefits associated with an undergraduate research program, including increasing the exposure and demonstrating the prestige of the institution to prospective students, increasing current students’ engagement, and building connections to alumni and the community.” (p. 22)</td>
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<td>“The results also indicate that students involved in research projects demonstrate deeper learning through higher order thinking, integrative learning, and reflective learning.” (p. 23)</td>
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<tr>
<td>“From a simple bookkeeping perspective, the costs associated with an undergraduate research program may</td>
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Despite recent interest in the impact of undergraduate research on student development, there has not been much work done on the relationship between participation in undergraduate research and the development of social science and humanities students. Using data from Truman State University, this paper found that students


-- A little dated (2002)

--- Students who participate in undergraduate research early on report significant gains in the ability to (1) think analytically and logically; (2) put ideas together, and note similarities and differences between ideas; (3) learn on their own and to find information they need to complete a task. Moreover, it was found that early participation in
who participated in collaborative undergraduate research with faculty early on reported significant gains in the ability to (1) think analytically and logically; (2) put ideas together; (3) learn on their own. Further, these gains were greater than those reported by students who did not participate in collaborative research with a faculty member. Moreover, it was found that early participation in collaborative research was of particular benefit for first-generation college students.


“...of particular benefit for first-generation college students.”
large research university, the authors make a substantial contribution to the literature on college retention and persistence in science education. They also explore the relationship of undergraduate research participation with high academic achievement in biology, which is necessary to pursue graduate education and become future scientists, science workers, and health care professionals. They detail existing research on this subject and their specific contributions to this body of literature. They conclude by suggesting that greater availability of undergraduate research experiences might counter some of the high attrition rates from science majors and contribute to attracting a diverse workforce to science careers. In particular, they find that between undergraduate research participation and graduation outcomes may be overly conservative for national trends.”

American students also had the largest gap between those that did research and those that did not in their probability of obtaining a biology degree.” (P. 106)

--- “Since underrepresented minorities have higher rates of attrition and lower levels of academic performance to begin with, research participation may particularly help prepare underrepresented minorities for graduate education and careers in the sciences, while providing a form of institutional integration into a competitive major at a large university.” (p. 106)

--- “When we consider the timing and duration of research and graduation in any major, participation in research during or after the third year or for one or more terms is strongly associated with college
Introducing students to undergraduate research early on and for an extended period of time are beneficial for the retention and performance of all students, but that underrepresented minorities may have the most to gain from such strategies.

Community colleges serve a significant proportion of underrepresented minorities in science, technology, education, and mathematics (STEM) fields, which includes 52% Hispanic students and 44% African American students. However, few minority and low-income students from community colleges transfer to 4-year institutions. Summer bridge programs that involve partnerships between 2-year and 4-year institutions are


Results are based on a small sample of 12 students.

---

In particular, we find that introducing students to undergraduate research early on and for an extended period of time are beneficial for the retention and performance of all students, but that underrepresented minorities may have the most to gain from such strategies.” (p. 110)

“Students start with an “introduction to research” experience with 2-year college faculty for 3 weeks in May, which is immediately followed by an 8-week research experience with research faculty at 4-year institutions.” (p. 14)

“The initial 3-week session supports students as they develop critical skills and scientific research “know-how.” These short projects also give students “hands-on”
promising mechanisms for successful retention in STEM fields. Herein, we report the implementation of an innovative undergraduate research model for students attending a 2-year institution. The "3+8" summer undergraduate research program offers 2-year college students an opportunity to engage in undergraduate research at nearby 4-year institutions. This experience provides a foundation that allows 2-year college students to successfully make the transition to STEM programs at the 4-year institution. In addition, these students will feel more comfortable in large research groups that provide a supportive environment for increased retention, progression, and ultimately graduation in a STEM discipline.

| | experiences with instrumentation and techniques not available in their academic labs at the 2-year institution but that are necessary for their upcoming summer research experience. (p. 14) |
| | “Participants felt that the research experience gave them a better idea of the field of study they wanted to pursue, helped them articulate the area of research they would like to focus on in the future, and allowed them to clarify their expectations about what research activities they might later be interested in doing.” (p. 16) |
Fostering resources for undergraduate research at the City University of New York. *New Directions For Higher Education*, (169), 73-83. doi: 10.1002/he.20124

activities is critical to a vibrant program. Strategies for obtaining funding are described in this chapter.

and retention but does not investigate how it does this.

Science Majors (PRISM) at John Jay College of Criminal Justice is one of the best examples at CUNY of a program explicitly focused on creating research opportunities for undergraduates that has led to the institutionalization of UR for the whole college.”

--- “PRISM funds are used for student stipends, a small supply budget for faculty mentors, travel to conferences, and preparatory courses for graduate entrance exams. As increased retention and graduation rates became evident, the college administration began to allocate more internal resources to the science department in particular and UR in general.”

--- “The PRISM program has also demonstrated that it provides an effective model for
creating successful student outcomes. Since its creation, student enrollment in UR has increased each year; PRISM students have contributed to a significant scholarly output that includes conference presentations and journal articles, and many PRISM students pursue advanced degrees.”

“Among the lessons learned from John Jay, Hunter, York, and NYCCT Colleges are that established physical offices of undergraduate research provide a focal point for both students and faculty.”

“The ability of the university to reveal the true power of UR as a high-impact practice requires a synergy between human and financial resources... The synergy, however, depends on individual

This chapter describes undergraduate research expansion in the Pennsylvania State System of Higher Education (PASSHE) in the context of both fiscal and student enrollment challenges.

Study is based solely on the PASSHE.

-- “Programs that support high-impact practices, such as undergraduate research, should be viewed as investments that provide a rate of return through the retention of students.”

-- “Several universities quickly realized that institutionalizing undergraduate research is connected to a broader effort of enhancing student success via high-impact practices, viewing the task as one that required cultural change on the campuses.”

-- “Deep involvement of faculty to drive initiatives from the “ground up.” These initiatives lead to grant support that engages students in a meaningful way; once a record of success has been established, administrative and institutional support often follows.”
the faculty is critical to increasing student success, retention rates, and graduation rates through their mentoring role in high-impact practices such as undergraduate research experiences."

-- “Many faculty members proposed ideas for additional funding to help support the undergraduate research expansion effort. Since the CUR workshops, several institutions implemented/planned summer undergraduate research grants under faculty mentorship.”

-- “By institutionalizing undergraduate research, PASSHE aims to enhance the way that students learn, faculty members teach, and courses are delivered to optimize student success. The impetus provided by participating in the CUR project enhanced the
integrity and quality of academic programs, and provided an opportunity to increase the success of undergraduate students through engagement in research experiences.”


This chapter captures the mission and spirit of the California State University in its efforts to institutionalize undergraduate research and support the success of students traditionally underrepresented in higher education.


The work focuses on Underrepresented Students only.

-- “Participation in undergraduate research is also linked to academic success, retention, and persistence. (Finley & McNair, 2013)”

-- “Here we discuss seven characteristics that the CSU is leveraging to benefit these students: Support Programs, Quality Mentoring and Role Models, Funding for Students, Authentic Opportunities to Calibrate Knowledge, Societal Relevance and Community Engagement, Links from Community College, Curricular Enhancements.”

“Until we can strengthen the business case, undergraduate research—
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<td>The article presents an example of an undergraduate research as a campus recruitment and marketing tool. It identifies undergraduate research in the Consumer Sciences department as a valuable marketing tool, as a tool to provide a competitive edge for students, and as a value-added incentive for faculty recruitment and retention. It emphasizes on undergraduate research which benefits the department’s recruitment and retention of majors with a value-added learning experience for students.</td>
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<tr>
<td>Article comprise four shorter articles giving a brief overview of UR at four small and specialised institutions.</td>
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| “We recognize three high-impact benefits of undergraduate research in Bradley’s Family and Consumer Sciences department: 1) as a valuable marketing tool for recruiting first-year students; 2) as a tool to prepare our students well for graduate school and provide a competitive edge for acceptance into their program of choice; and 3) as a value-added incentive for recruiting and retaining faculty who might otherwise not consider a career at an institution primarily focusing on undergraduate
-- “The most successful marketing tool for undergraduate research has been Endeavors, an annual magazine developed collaboratively by LUROP and the university’s Office of Research Services. It features short articles (400-450 words) profiling a student in each of the LUROP programs.” (p. 47)

-- “In each student profile, readers get a snapshot of the broader impact of research on undergraduates, such as how it helps them refine goals for their careers or graduate school, develops an appreciation for how research complements coursework, provides insight into the greater purpose of research and scientific inquiry, and sometimes develops a new understanding of social-justice issues.” (p. 47)
Recent reforms in engineering education have emerged to meet the changing needs of engineers, however sparse research exists that comprehensively assesses the outcomes associated with such engineering education efforts. Accordingly, there is an urgent need for educational approaches tied to assessing engineering students’ performance, retention, and impact. This study’s purpose is to explore the relationship between sequential chemical engineering degree projects and students’ performance, engineering efficacy, multidisciplinarity, and retention. The projects for this education for chemical engineers research are thematically focused laboratory


Focuses exclusively on Chemical Engineering students and degree projects.

Modest sample size.

- “the researchers designed and implemented a new pedagogical approach, undergraduate degree projects, that combines problem-based learning with long-term experimentation project that builds upon itself, course-by-course with gradually increasing complexity in inquiry from freshman to senior year” (p. e70).

“The degree projects approach to undergraduate chemical engineering education is clearly an impactful approach for undergraduate engineering programs. These practices are easily generalizable to other undergraduate and graduate engineering and science fields in universities and colleges.
experiments embedded in a four-year chemical engineering program. Each project component is connected to the next, is increasingly complex as courses advanced, and is aligned with essential course content. This connectivity enables students to participate in logically sequenced experiments that culminate in well-developed senior laboratory projects. This study’s educational impact was determined via comparison between seniors’ and freshmen’ performance, efficacy and retention. Results of this research indicate that the use of degree projects in chemical engineering education is impactful, resulting in students’ increased understanding of experimentation and course content; meaningful, resulting in statistically significant increased student

Accordingly, given the theoretically aligned design of this inquiry-based reform effort, it is easily scalable across engineering and scientific academic disciplinary education. The degree project approach is also highly applicable to engineering educational program accreditation and certification efforts and other academic protocols because the metrics used to measure the reform’s impacts are direct measures of “hard” and “soft” engineering skills and competencies, thereby representing direct alignment with various indicators of chemical engineering competence in the field internationally.” (p. e76)

The benefits of student engagement in undergraduate research are well-recognized by many higher education institutions. Increased emphasis on undergraduate research in these institutions has taken many forms resulting in considerable differences across institutions ranging from "light touch" to "heavy duty" involvement of students in the research process. We surveyed 44 undergraduate students who participated in undergraduate research projects in one mid-western university. The survey measured student effort and perceived benefits from undergraduate research. Students were asked to report the number of hours that they spent working on the project and the hours their mentors worked on the projects based on their own recollection and their perceptions, which may be of limited accuracy. Students were also reporting on the benefits they perceived, which may not entirely encapsulate the benefits of undergraduate research.

---

"This finding indicates that there is a strong direct relationship between time spent on research and increasing knowledge about the safe and ethical conduct of research." (p. 8)

---

"Student’s research work has been helpful in improving skills related to networking, improving professional credentials, and contributing to a body of knowledge. The skills from this subscale are skills that will help prepare undergraduates for their future careers." (p. 8)

---

"Although greater time invested by students was
benefits along many dimensions. Our findings reveal that the total hours worked on research projects is significantly and positively correlated with perceived benefits by students. At a more granular level, student effort was specifically linked to benefits in the areas of communication; data collection; professional development; personal development; professional advancement; information literacy; responsibility; and knowledge. Additionally, the total time spent on the undergraduate research project by the research mentor/faculty positively correlated with student effort. Furthermore, higher student effort also evidenced a higher intent to publish the research. Exploratory analyses examined if specific types associated with greater benefits, greater student time was also associated with greater involvement of mentors.” (p. 9)

--- ”It may, in fact, be the case that when universities want to enhance undergraduate research opportunities, the university should also plan for additional resources such as faculty time.” (p. 9)
of work correlated with total benefits. Findings revealed that the total benefits score was significantly positively correlated with tasks including developing a theory or conceptual model, defining the sample, interpreting the findings, and preparing the written report. Thus, our findings strengthen the current trends of increased emphasis on undergraduate research across the board in higher education institutions, and they suggest that "heavy duty" involvement may be most beneficial for students.

of learning outcomes, including preparation for careers or graduate schools and higher-order thinking. A majority of respondents cited that undergraduate research was a positive factor in their actual admission to employment or graduate school.

positive relationship between student-faculty research and deep learning, as well as gains in general, personal, and practical learning. Specifically, undergraduate research helps students achieve desired learning outcomes that include "practicing integrative and applied learning" and "strengthening intellectual and practical skills" (Kuh 2008, 6).

-- "In the open-ended comment area provided for respondents to elaborate on their responses regarding graduate school, the majority of the 44 comments stated three main themes: Undergraduate research gave an advantage or was an outright necessity for admission; it was a topic of discussion during interviews or in application letters; it allowed students to jump-

Retaining college-level science, technology, engineering, and mathematics (STEM) students remains a priority in higher education. A variety of methods have been shown to increase retention, including mentorship, tutoring, course enhancements, community building, and engagement in high-impact practices such as undergraduate research. In 2011, an Office of Undergraduate Research at a large research university developed a program that incorporates multiple forms of student-centered programming with a focus on research. Learning Environment and Academic Research Network (LEARN) is a study based on students from one institution only.

Study is based on students from one institution only.

---

“Two significant outcomes of this program are the long-term retention and higher GPAs of students compared with those in the matched control group throughout the students’ college experience” (p. 42)

“In summary, our data indicate that the LEARN program successfully recruited underrepresented and first-generation students. The students involved gained critical thinking abilities, earned higher GPAs, and had higher retention rates at the beginning of their undergraduate career. Programs such as LEARN provide positive experiences for students during their first year,
living-learning community wherein first-year students live in the same residence hall, take specific classes together, work with mentors, and engage in a 12-week mentored research apprenticeship. LEARN aims to recruit first-generation and underrepresented students. Such a program requires input and participation from numerous stakeholders. This article provides reviews of the development, implementation, and lessons learned from starting the program. To date the program has many early signs of success, including exceeding recruitment goals, higher GPA and retention rates, gains in student learning, and high levels of engagement in academic and leadership experiences. 

create a small community for students at a large university, and create partnerships campuswide to support student success, satisfaction, and retention. We believe that other universities could adapt our program. For example, four-year universities without graduate students could use upper class undergraduates as the research mentors. Similarly, nonresidential campuses could create community without the living component for first-year students or transfer students. There are many components to the program that could help attract, excite, retain, and graduate future scientists and engineers.”

17. Schneider, K., & Bickel, The article examines [http://ezproxy.uvu.edu/lo](http://ezproxy.uvu.edu/lo) The article concentrates -- “Additionally, 48
| University of Central Florida's (UCP) learning community Learning Environment and Academic Research Network (LEARN) that focuses on STEM education. An overview of the LEARN program is provided which offers a research apprenticeship to students. Also discussed are the benefits of the program for students, the design of the apprenticeship program, and UCP's partnership with the National Science Foundation for the program. |
| more on the Graduate Students mentoring the Undergraduate Students rather than the Undergraduate Students experience. The article states that the Undergraduate Student experience is dependant on the strength of the the Graduate Mentor. |
| | percent of LEARN participants are first-generation college students and 77 percent have been from populations underrepresented in graduate education. The program has produced significant outcomes for participants such as increased retention and higher GPAs compared to a matched control group, as well as significant positive gains in critical thinking as measured by the Critical Thinking Assessment Test. (p. 2) |
| The article focuses on the aspects of the undergraduate research (UR) program for the professional disciplines at Bridgewater State University. Topics include the various strategies provided by the university to provide pre-professional research opportunities, the UR |
| Study is based on finding from one institution only. |
| -- “Undergraduate research is a prime way for first generation, low-income, and minority-group students across the country, including at Bridgewater State, to distinguish themselves academically and become sought-after candidates in a competitive environment.“ (p. 1) |
opportunities offered by the university for several university's courses including education, business management, and social works, and the inclusions of the faculty mentors and students.

-- “Because UR provides pre-service teachers with the skills they need to become thoughtful, purposeful, professional educators, several faculty members in the Department of Elementary Education and Special Education at Bridgewater State have intentionally woven research assignments into 200-level introductory courses, as well as into upper-division methodology courses.“ (p. 3)

-- “ Students in CSD attest to mastering the material in the courses in which they conduct research, as opposed to, as one student put it, "standard lecture and PowerPoint" courses.” (p. 5)

-- “Employers want to hire college students and recent graduates who can accurately identify problems, seek alternative
approaches, think critically, derive solutions, interpret data to make informed decisions, and communicate their insights to stakeholders. Faculty who are interested in improving students' critical-thinking and problem-solving skills cannot simply rely on assigning the standard cases described in textbooks. Through UR they can provide much more valuable opportunities for students to improve their skills, and therefore their marketability, through hands-on experiences.” (p. 7)

The UR program at Bridgewater State has successfully employed several strategies for including faculty mentors and students from professional disciplines in the university's range of UR opportunities—from summer and semester grant-funded projects, to
The article presents a study regarding the necessity of undergraduate research to improve retention of students in science fields. A survey was conducted to new biology graduates with regards to mandatory research project. A chi-square test was utilized to determine their voluntary engagement in research project. It mentions that mandatory research is an effective tool for the future career students to become scientists.


Study is limited to Underrepresented Students at a single institution.

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"These results, while preliminary, strongly suggest that mandatory research experiences may be a significant mechanism for engaging African-American females in the science, technology, engineering, and mathematics (STEM) pipeline—students who might otherwise have been lost to it." (p. 17)

---

"First, requiring a research experience in no way diminished the benefits perceived by students, whether or not they decided on their own..."

The immediate benefits of research experiences for undergraduates have been documented. However, little has appeared about the long-term impacts of these experiences on participants' career trajectories and their level of career satisfaction. In addition, many studies of undergraduate research lack a comparison group. This article reports a comparison of results from a survey of participants in the University of Arizona (UA) Undergraduate Biology Research Program (UBRP) with those of a study limited to students in the Life Sciences.


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Study is limited to students in the Life Sciences.

-- “Most of the UBRP group felt their research experience had an effect on their choice of career and level of career satisfaction. Over 80% believed that their undergraduate research experience had a substantial effect, including 46% who felt that it was critical in their career choice” (p. 5)

-- “The higher rate of response to this survey by UBRP participants compared with COM participants suggests that an organized undergraduate research program positively fosters..."
comparable group drawn from the UA College of Medicine who did not participate in UBRP. Findings indicate that exposure to undergraduate research clarifies career paths and demonstrates to many students that they have an aptitude for scientific research that has a strong effect on their professional development. Participation in research for many who pursue medical careers tends to be "instrumental" in that it is seen as a means of becoming a more competitive medical school applicant. Both the UBRP group and the College of Medicine group indicated that mentors were key to determining and achieving their professional success. Response rates suggest that an organized undergraduate research program fosters a feeling of identification with the institution.” (p. 7)

-- “Undergraduate research appears for many students to be a transformative experience. That is, participation in an actual, ongoing research group helps students to clarify their career paths.” (p. 7)
of community and engenders an enduring sense of loyalty within a large institution

Trade Articles:

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Similarly, undergraduates can learn the conventions of research through imitation and practice”.

-- “Coaches are fond of noting that participation in collegiate athletics builds teamwork and character, thus making a permanent contribution to students’ lives. In the same way, undergraduate research -- which involves checking facts, forming carefully worded hypotheses, and supporting a particular viewpoint without becoming emotionally involved in it -- is excellent preparation for any career.

-- “In addition, undergraduate projects are a way for departments to evaluate themselves. When a student fails to achieve as expected on a senior thesis, it becomes a time of soul-searching for all the members of the department.
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<td>What good is undergraduate research, anyway?</td>
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<td>-- “They found that undergraduates learn and grow significantly from their research experiences, but require a strong mentor relationship to do so”</td>
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<td>-- “The three studies largely agreed on their conclusions — they found similar gains in undergraduate learning and effects on students' career paths — and their results largely reflected the accepted wisdom.”</td>
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<td>-- “In a small that she hopes to expand, Ms. Hunter, of the University of Colorado found that &quot;students that didn't have a positive experience were doing more-mundane and routine tasks rather than being involved in the actual science of the project.&quot;</td>
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Indeed, the faculty members interviewed by Ms. Hunter and her colleagues from Colorado tended to present a less rosy view. In the interviews, faculty members mentioned the costs of doing research with undergraduates twice as often as the benefits.

Ms. Hunter says the family strains for faculty members can be profound: "They're dedicating their lives to other people's children and maybe not putting in as much as they'd like with their own family." They also struggle with balancing their own research goals with the need to educate their students.


Trade article. Letter to the editor. A little dated.

-- "Yet we are familiar with many faculty members who believe that an essential feature of undergraduate research is that the problem be authentic,
with the hope of publishable success and the risk of complete failure. For these mentors, to settle for "pretense" would be to thwart the value of the experience.


-- “Students in the honors program that I have been directing for the past two years have consistently pointed to their senior thesis as the most substantive learning experience of their education.”

-- “The Research Experience for Undergraduates Site program, as the Web site explains, "supports active research participation by undergraduate students in any of the areas of research funded by the National Science Foundation."

-- “Learning in a classroom is very different from learning in a community..."
These communities are (1) enduring and (2) multigenerational groups who coalesce around a shared research theme, and that (3) intentionally develop 'capacities of effective practice,'

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“So if a curious student comes to you this semester looking for an independent study or an intensive research experience, and you really don't have the time to take on one more obligation, consider pointing that student to the REU Web site, and encouraging him or her to take advantage of an opportunity to engage in a deep, collaborative, and exciting research process.”

Trade article. A little dated.  
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“Students need role models. I often brag about "fish" I have caught in the past, and whenever possible I bring those students to class so my
current students can see what opportunities are available to them, and what they can accomplish.

-- “Research has shown that it takes one and a half to two years to establish a mentoring relationship in a university setting. In my experience, the liberal-arts setting, and especially a one-on-one research relationship, speeds up that process and is very effective at breaking down barriers between professors and students.

-- “That might be changing, however, because some faculty members at liberal-arts colleges are adopting a big-university research model to become more productive researchers, a change that their administrators believe will help improve the colleges’ rankings. Those professors are no longer using their own rods and reels but are hiring postdocs and
technicians to do most of the research, placing a layer between themselves and undergraduates. As a result, they are reducing their ability to become effective mentors.