Bronco Scholar - An Online Hub for STEM Student Research

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In order to maintain the United States' preeminence in science, technology, engineering, and mathematics (STEM) fields, the country must produce approximately one million more STEM professionals over the next decade than the projected current graduation rates.[1] To attain this goal, policymakers aim to increase STEM retention in college, arguing that it is a low-cost, fast way to produce more graduates with the training and expertise that the nation needs in STEM fields.[1] According to a 2014 report by the National Center for Education Statistics, some reasons for attrition from a STEM major are derived from two extremes of the spectrum include achieving lower STEM grades compared to non-STEM grades or taking lighter and less challenging STEM courses in the first year of college.[2] Feist suggests that the earlier an individual finds a sense of interest and accomplishment, the sooner he or she will commit to a given goal,[3] in this case pursuing a future in a STEM field. By refraining from taking more challenging courses, a student is less likely to find this fulfillment in a STEM talent and seek success in a non-STEM major. One solution, a commonly cited best-practice for increasing participation in STEM, especially in low income, underrepresented minority and first generation students, is undergraduate research. Conducting research in a student's major develops a reflective understanding of his or her own field and is an effective way to provide the student with a deep learning and engagement experience that are closely connected to those faculty and advanced peers.[4] In this way, student motivation and aspiration is encouraged by interactions with high-achieving peers and faculty who help students realize the application of what they learn in the classroom. To address the nation's call to produce more professionals trained for STEM fields, the National Science Foundation Science, Technology, Engineering and Mathematics Talent Expansion Program (NSF-STEP) at California State Polytechnic University, Pomona (CPP) has focused efforts to retain students through increasing the opportunities for students to be exposed to and participate in undergraduate research activities. This paper explores the impact of an institutional electronic repository on the broader campus.

The Council on Undergraduate Research defines undergraduate research as "an inquiry or investigation conducted by an undergraduate student that makes an original, intellectual, or creative contribution to the discipline".[5] Undergraduate research provides an environment for students to develop personally, academically, and as a scientist.[6] Participating in research has benefits including an increase in confidence and GPA, development of critical thinking and problem solving skills, and clarity about future education and careers in science.[7] Research unaccompanied by dissemination, however, makes the research process incomplete. Publishing original research is the culminating step in the research process and an exceptional piece of research will not matter if no one ever gets a chance to read it and to use it to inform future scholarship, policies, and/or decision making.[8] Not only does publishing the results of the research complete the project, but it also provides its own set of benefits including professionally presenting a representation of completed undergraduate work, receiving feedback from a broader community, increasing chances of graduate school acceptance, and distinguishing oneself in the job market.[8] Dissemination activities include poster presentations, participating at conferences, and publishing in journals. However, at the undergraduate level, certain opportunities are harder to come by than others and consequently, the level of exposure is limited based on the activity. For example, although roughly 20% (approximately 4,000 students) of all CPP students annually participate in undergraduate research, only 2 to 15 undergraduate students publish their work in

peer-reviewed journals. Considering this number creates the illusion that only the most accomplished students can participate in research, making research seem out of reach for many under-served students. Additionally, without a consistent source of undergraduate research products available, students who are interested in research are left unaware of the types of research being conducted on campus, the level of research on these projects, and the quality that is expected of them. For those students who are able to pursue research, though, traditional publishing opportunities may still be out of reach, however, an institutional repository can offer alternative publishing opportunities for showcasing research projects.

In conjunction with creating a culture of research at CPP, the NSF-STEP team has collaborated with the University Library to establish an online repository, Bronco Scholar, which provides persistent and reliable access to published scholarly and creative outputs of CPP faculty, staff, and students. Prior to the development of Bronco Scholar, most students conducting undergraduate research presented their project achievements and results through oral and poster presentations at their college symposiums and seminars. These scholars were limited to basic levels of dissemination, reaching only the small audiences who were able to attend the presentation at the given time, and without a consistent channel to reach a wider set of scholars at any other place or at any other time. To resolve this limitation, Bronco Scholar was established to provide this needed consistency, and serves as the hub that connects undergraduate research to the scholarly community. Not only are the student researchers now able to share their work with a broader audience, but a wider range of scholars are able to view samples of scholarly work at CPP. Also, new and interested researchers are able to look up projects that were performed by their peers to get information and motivation to conduct research, and more importantly realize that research is a possibility for them.

What is Bronco Scholar?

Institutional repositories have been a growing force in academia for nearly two decades. Clifford Lynch, the Director of the Coalition for Networked Information, published one of the more widely used definitions of an institutional repository in 2003, stating:

> A university-based institutional repository is a set of services that a university offers to the members of its community for the management and dissemination of digital materials created by the institution and its community members. It is most essentially an organizational commitment to the stewardship of these digital materials, including long-term preservation where appropriate, as well as organization and access or distribution.[9]

Raym Crow stated that institutional repositories "capture the original research and other intellectual property generated by an institution's constituent population active in many fields."[10] According to Jonathan Nabe, the three most prominent benefits of a campus repository are increased access, higher visibility, and improved preservation.[11]

Despite opportunities for scholars to participate, institutional repositories were not quickly adopted across campuses upon their initiation. The earliest institutional repositories faced challenges with encouraging faculty to deposit, issues obtaining sufficient staffing, and general institutional support. Dorothea Salo describes these challenges and others in her article

about her experiences as an institutional repository manager attempting to encourage faculty submissions.[12] Over time institutional repositories have grown beyond serving as an archive for pre-prints and post-prints of faculty publications; institutional repositories now are more likely to feature a broader representation of campus scholarship.

The initial development of Bronco Scholar was intended to support the NSF-STEP grant at CPP by creating sustainability for the learning objects that were created through the early years of the grant but had no mechanism for sharing or dissemination. The PIs for the NSF-STEP grant were also interested in featuring and curating student work for the purpose of documenting the frequency of undergraduate research on campus and in providing dissemination opportunities for undergraduate researchers. So, in February 2014, after an eight month planning and testing period, Bronco Scholar was launched with the additional goals of increasing student interest in undergraduate research; facilitating collaborations between students and faculty mentors by providing a searchable space for finding faculty mentors with similar research interests; helping students understand expectations and opportunities in undergraduate research by referencing works in the repository; and providing a showcase for student work created at CPP. CPP was interested in concentrating initial repository efforts on featuring undergraduate research due to various factors including an active community of faculty members supporting undergraduate research, the initiation of an Office of Undergraduate Research, funded grants supporting undergraduate research initiatives, as well as the role of CPP as a predominantly undergraduate teaching institution.

As a campus in the California State University (CSU) system, the University Library at CPP had access to a consortial instance of DSpace provided by the CSU System-wide Digital Library Services. DSpace, one of the most common institutional repository software alternatives, has nearly 1,500 installations worldwide as reported on the DSpace website.[13] Participating in a consortial instance of a repository allows Bronco Scholar to be housed alongside a wealth of student research from across the CSU campuses.

Bronco Scholar is an open access repository meaning that anyone in the world can access the stored scholarship without requiring logins or registrations. According to the Scholarly Publishing and Academic Resources Coalition (SPARC), "open access is the free, immediate, online availability of research articles coupled with the rights to use these articles fully in the digital environment".[14] Because open access materials are freely available, both students featuring their work in Bronco Scholar and students accessing completed work stand to benefit from wide accessibility of student research.

Bronco Scholar has been marketed in various ways to the campus community. Shortly after launch, a marketing plan was developed for the purpose of informing the campus community of the new service. Goals included educating faculty members on the benefits of the repository; encouraging faculty to work with students with exemplary work to submit; increasing public awareness of Bronco Scholar; and educating the CPP community about open access. Initial marketing campaigns included advertising Bronco Scholar via digital marketing channels such as the library website, digital signage, through newsletters, faculty email announcements, and via campus media channels. A brochure was created, which was shared at faculty department meetings across the campus. Project leadership also developed a "talking points" document to

train librarians and library staff on the main benefits of Bronco Scholar for faculty and students. A mandatory information session was scheduled for library staff and workshops were presented for students in which the benefits of Bronco Scholar and open access were discussed. The marketing materials produced for Bronco Scholar have been shared with local institutions for use as a guideline to improve or create their own institutional repositories.

By requiring faculty approval, Bronco Scholar maintains the standard of showcasing only exemplary work. Both students who submit to Bronco Scholar as well as those who access Bronco Scholar benefit. Bronco Scholar serves as a point of reference for students who are interested in undergraduate research, allowing students to search the type of inquiries that are being explored on campus and who is involved in the projects, as well as figure out how they can get involved themselves. An important effect of referencing Bronco Scholar is leaving the impression on students that research is available and achievable at this point in their academic career. In addition to the professional and academic benefits of publishing work to Bronco Scholar, student researchers begin to see the value of their own scholarly contributions and begin to seek more proactive pursuits of dissemination opportunities. With the generation of stable URLs, student researchers are more able to share their works on their social and professional profiles such as LinkedIn, Facebook, and graduate school applications. More and more repositories are starting to feature undergraduate research as well; Utah State University has built profile pages for graduate students in select departments and mention the benefits of providing a dissemination platform for students including stable URLs and an online showcase of student research.[15] In providing a permanent and reliable space for undergraduate scholarship, students are able to create and build upon a stable foundation of research that future students can rely on for generations to come.

Impact of Bronco Scholar

Through an institutional repository, it is possible to track different types of standard web statistics such as unique users, page views, session length, and location. The impact and success of a repository hinges on more than web statistics; the most prevalent statistic for tracking repository success is a repository download. This means that a user visits the repository and downloads a copy of the final research product whether that is a paper, a PowerPoint presentation, a poster, an abstract for a conference, or other significant submitted work. Certainly web statistics can be valuable for tracking interest in certain topics or general traffic, nevertheless, a download means that the user completed a repository goal by accessing the actual research output. Therefore, the following discussion of statistics and impact refer to downloads in the repository.

Bronco Scholar is, in comparison to other more established repositories, still in its fledgling stages. Regardless, usage has increased dramatically when the first two years of the repository are compared. The collection has increased from 55 learning objects since launching to over 700 objects with a projected growth of over 500 objects yearly. Between 2014 and 2015, downloads increased by 229%, despite only a 90% increase in the amount of items available in Bronco Scholar.
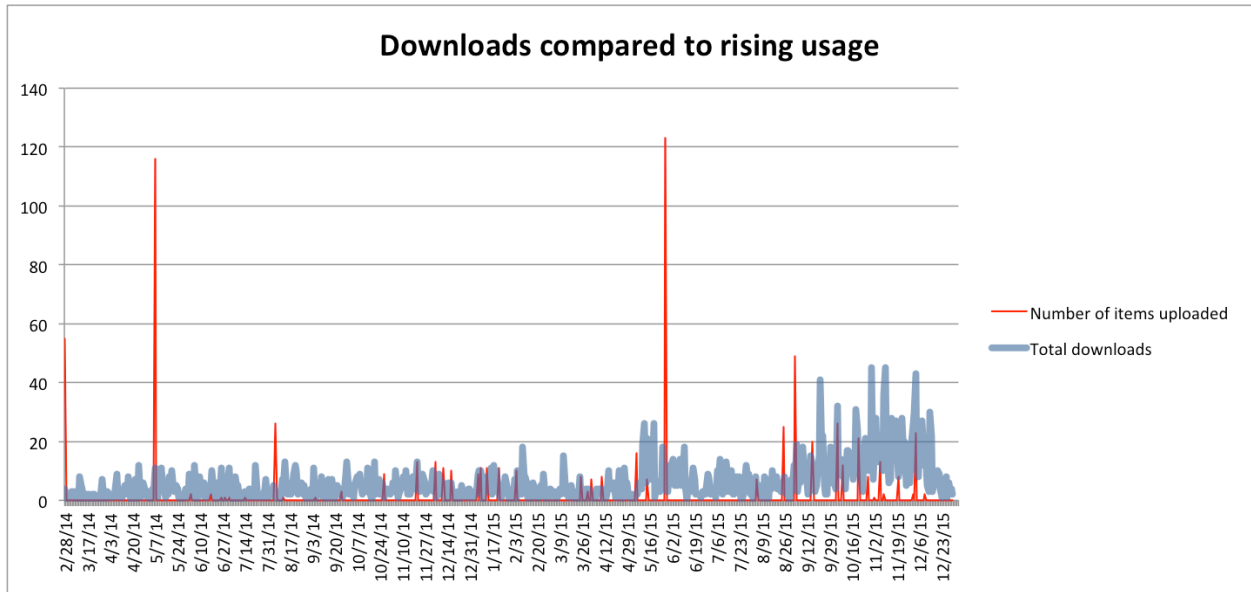
Figure 1 Number of item downloads compared to item uploads from 2014-2015

Just over 20% of downloads originated from the Pomona area since Bronco Scholar's launch, likely from those associated with CPP. Of those users, 83% downloaded student research. Many students at CPP commute from various locations in Southern California. When looking at the Los Angeles Metro area, this usage doubles. Nearly 40% of downloads occur from users in the Los Angeles Metro area. Those users predominantly download student research with more than 86% accessing undergraduate student research, conference abstracts, graduate theses, projects, and dissertations, and an undergraduate student journal. Bronco Scholar's usage is consistent with usage from other regions where over 88% of users access student research objects.
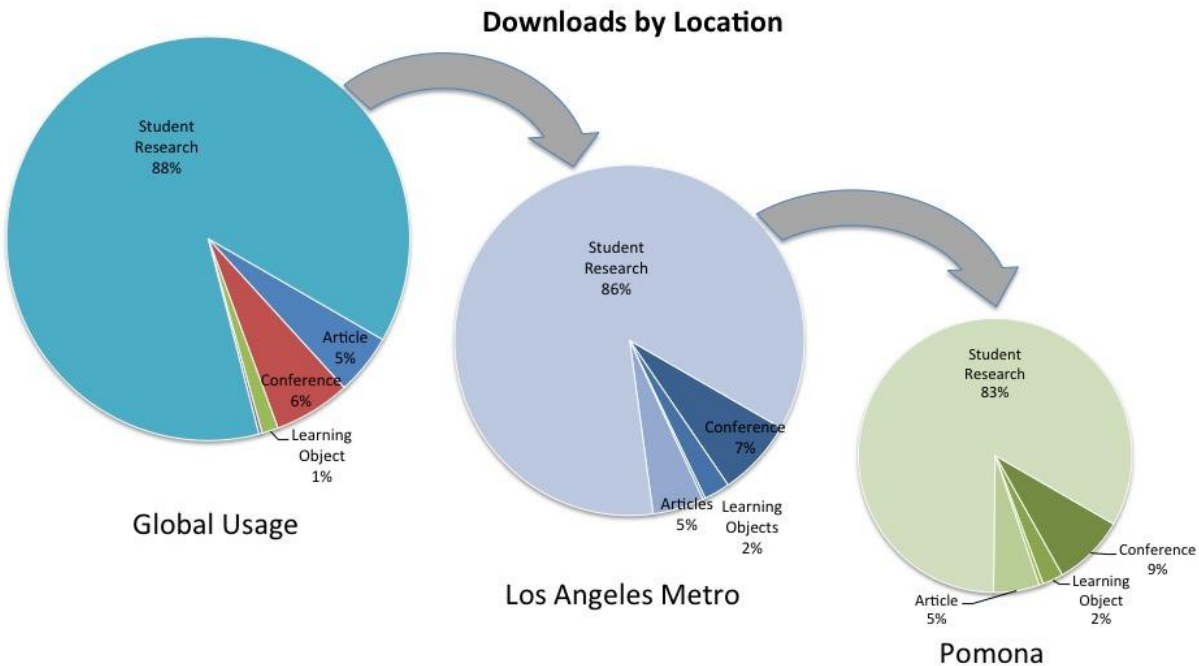
Figure 2 Bronco Scholar item downloads by location

A tracking system for campaigns was implemented in the web statistics software for Bronco Scholar and staff began monitoring peaks in usage. Over the past year, the library has tracked the benefits of social media for publicizing the repository. A few students posted Bronco Scholar links to social media pages and profiles, creating spikes for their content. Both the library and the Office of Undergraduate Research subsequently began featuring individual undergraduate scholars with research in Bronco Scholar by posting links to social media. Additionally, the library began developing banners and announcements on the web when new collections were made available. These activities have helped to publicize the launch and increase usage of Bronco Scholar over time. A few robust undergraduate research programs were included in the early offerings of the institutional repository, including the Ronald E. McNair Post Baccalaureate Achievement Program, and contributions from a newly established campus-wide Student Research Conference. Contributions from the McNair Scholars Program and the Student Research Conference continue to be added annually. In addition, a number of other campus programs have begun to participate. Bronco Scholar features student scholars from two new grant funded initiatives: the Achieve Scholars and the Engineering Scholars. Other student conferences are also targeted for participation; the Office of Undergraduate Research initiated a student summer conference in 2015, the CARS Symposium, and abstracts, presentations, and posters from this conference are curated in Bronco Scholar. Select participants in external conferences such as the Southern California Conference on Undergraduate Research, a Summer Bridge program with a community college, and the CSU Agricultural Research Institute have also deposited their research in Bronco Scholar.

Initial demographic data supports the theory that CPP students are benefitting from the undergraduate research available in Bronco Scholar. Since Bronco Scholar is publicly accessible, we are unable to determine who individual users are because no log in is required. We have, nevertheless, begun to track certain demographic characteristics of users of Bronco Scholar through Google Analytics, which lead us to believe that students are the primary users. For instance, current preliminary demographics information indicates that nearly 50% of all tracked users of Bronco Scholar are between the ages of 18 and 24. CPP institutional data indicates that 83% of students are under age 25.[16] While we cannot assess whether all of these tracked users are CPP students, we can assume that 50% of users are college age. As previously mentioned, 20% of users are located in Pomona with nearly 40% in the greater Los Angeles area. It is likely that many of these college age users overlap with the local users. Therefore, it is probable that many of these local users are CPP students.

As mentioned earlier, the use of an institutional repository for student research by itself is not innovative. Many universities are featuring student research, especially graduate theses and dissertations. Many undergraduate focused institutions feature undergraduate research in their repositories as well. What differentiates Bronco Scholar is that it was founded with the purpose of focusing on student research; subsequent activities and usage of the repository has cemented this purpose. CPP has a number of undergraduate research programs that recruit students. Bronco Scholar features participants from many of these programs by creating profile pages featuring their work. Featuring faculty in this manner is a common practice for many institutional repositories; Bronco Scholar is exceptional because the students' exemplary work is featured.

Students with profile pages have a static representation of their successes at CPP. Few other university libraries are featuring students in this manner, especially undergraduate students.

Figure 3 Example of an undergraduate student profile in Bronco Scholar

Discussion

Although students are familiar with the scientific method, many often overlook the culminating step – communicating the results to the scholarly community. Therefore, while they may gain the benefits of participating in undergraduate research, they miss the benefits of effectively disseminating their accomplishments. Still, there are students who enter the research experience with the intent of publishing their research, however realize that publishing is rarely possible in the span of just one or two semesters.[7] Limited to presenting at symposiums and conferences, sustainability is cited as the greatest challenge for undergraduate research programs.[17] By submitting work into an institutional repository, not only does a student's research become more permanent, but it also increases the student's level of exposure and recorded achievement. Provided that in order to submit a piece to Bronco Scholar, a student must have the written approval of his or her faculty mentor, all submissions have been through a review process to ensure that Bronco Scholar is a showcase of excellence.

Knowing that the possibility of non-traditional publication is open to all student researchers and that there are examples of high quality work available to them, students are encouraged to set out on their own research experience for the first time. Being aware of the resources and information that the University Library has to offer helps to demystify the publishing process and that the requirements to get involved in a research project is within their reach. While more advanced researchers are aware of the benefits that accompany participating in original research, this information is new to undergraduates who are unaware that research opportunities exist on campus or have never been exposed to the idea of research. Accessing Bronco Scholar shows that undergraduate research is more than an educational exercise, but that completion of the full research cycle by publication is a realistic possibility,[6] especially at their level in their academic careers. By accessing content of interest, a student is given enough information to connect with a scholar or mentor who is experienced in the process, and who can guide the student in pursuing his or her own academic investigation. Currently, Bronco Scholar is exceeding initial expectations for content collection and web usage. Student research continues to be the most used content in the repository and the library is receiving additional requests from both faculty and students to feature new content.

In 2006, the University Library had investigated repository services with the purpose of disseminating graduate theses. At that time, the library faced many challenges convincing faculty of the benefits of repositories. In the last decade, it appears that these attitudes have changed drastically. Many faculty are excited by the potential of including their students' research in Bronco Scholar. Faculty are quick to respond positively to approval messages for student submissions and many faculty have lauded the benefits of Bronco Scholar for tracking undergraduate research endeavors. This shows a shift in ownership of faculty/student research projects. Faculty at CPP are more likely now to encourage their students to disseminate shared research and to take collaborative ownership of that research.

Conclusion

There have been many reports emphasizing the benefits of undergraduate research and on how to involve more students in research activities. However, creating sustainability of these research activities and promoting the dissemination of student findings have been challenges, especially for undergraduate students who have limited resources and opportunities. By developing Bronco Scholar, CPP has addressed this issue by providing a permanent and consistent platform that houses scholarly work by the CPP community and features student research. In featuring student work, Bronco Scholar fosters the undergraduate research culture that is becoming more prevalent on campuses nationwide, but also the success of the students who access the repository. As an open access resource, objects within the repository reach scholars over a wide geographical span, allowing students to disseminate their works to a vast community, but also attracting viewers to the idea of research. Although Bronco Scholar is young in its development, the repository has already exceeded its expectations in content collection and web usage, and has a promising future. It is our hopes that Bronco Scholar becomes an established name on campus as the primary place to search for exemplary undergraduate research and to publish student work, as well as become a model repository from which other institutions can model their own repositories to include undergraduate research.

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