New Orleans JAZZED about Engineering Education

Paper ID #15375

An Academic Library's Role in Improving Accessibility to 3-D Printing

Mr. Daniel P Zuberbier, East Carolina University

Dan Zuberbier is the Education & Instructional Technology Librarian at East Carolina University (ECU). He planned for, launched, and currently manages the J.Y. Joyner Library 3D printing service which makes 3D printing accessible to all students, faculty and staff at ECU, and is currently developing a course on 3D printing for the North Carolina Summer Ventures in Math & Science Program. He previously worked as a high school Social Studies teacher in Arizona and Michigan, and holds an M.L.I.S. from the University of Wisconsin-Milwaukee. His professional interests include teachers' perceptions of school library programs and school librarians as a resource and assisting educators with integrating emerging technologies into the classroom.

Dr. Ranjeet Agarwala, East Carolina University

Dr. Ranjeet Agarwala serves as an Assistant Professor in the Department of Technology Systems at East Carolina University. He holds a PhD in Mechanical Engineering from the North Carolina State University. Since 2001 he has taught courses in Engineering Design, Digital Manufacturing, and 3D printing, GD&T, Electro-Mechanical Systems, Statics and Dynamics. His research interests are in the areas on Advance and Digital Manufacturing and its integration with the renewable energy sector.

Mr. Mark McKinley Sanders, East Carolina University

Mark Sanders is the Assistant Director for Public Services at East Carolina University's (ECU) Joyner Library. Previously he worked as a Reference and Outreach Librarian at ECU and Louisiana State University. He holds an M.S. in Library Science from UNC-Chapel Hill and an M.A. in Spanish literature from Penn State University. His professional interests include student centered learning spaces, innovative services, and new technologies.

Dr. Robert A. Chin, East Carolina University

Robert A. "Bob" Chin is a full professor in the Department of Technology Systems, College of Engineering and Technology, East Carolina University, where he has taught since 1986. He is the past director of publications for the Engineering Design Graphics Division and the past editor for the Engineering Design Graphics Journal. Chin has also served as the Engineering Design Graphics Division's annual and mid-year conference program chair, and he has served as a review board member for several journals including the EDGJ. He has been a program chair for the Southeastern Section and has served as the Engineering Design Graphics Division's vice chair and chair and as the Instructional Unit's secretary, vice chair, and chair. His ongoing involvement with ASEE focuses primarily on annual conference paper presentation themes associated with the Engineering Design Graphics, the Engineering Technology, and the New Engineering Educators Divisions and their education and instructional agendas.

An Academic Library's Role in Improving Accessibility to 3D Printing

Abstract

This paper focuses on several initiatives that have been implemented at an academic library to improve accessibility to 3D printing for its campus community. This project, and its engineering and technology educational components, have evolved from a direct collaboration between the College of Engineering and Technology and the main campus library. Resources have been published for educating, training, and automating in order to increase access to the University's 3D printing resources. 3D printing workshops have also been offered to students, faculty and staff to improve their understanding of 3D printing technology. While the time devoted to training varies, all training is lab-based and hands-on. Workshop participants have come from a diverse array of disciplines within the natural sciences, health sciences, humanities, and the social sciences. Faculty members from different colleges, departments, and disciplines have brought their classes to the library so their students can explore 3D printing technology. In less than a year, this initiative has grown and become a full-fledged campus wide endeavor with more growth expected. This paper reports on the model and methods that have been adopted to foster the success of this initiative.

Introduction

3D printing is fast becoming ubiquitous and sparks comparisons to the proliferation of personal computers several decades ago. Like the computer in the mid-1980s, there is pent up demand for access to 3D printing, including training, access to the systems, and the opportunity to produce products. While schools and public libraries have led the charge in providing greater access to 3D printing, higher education has moved at a more methodical pace. Traditionally, in academe, 3D printing has only been available to a limited segment of the campus community, but it is gaining attention and new audiences are clamoring for greater access.

A decade ago Ramaley and Zia had the foresight to recommend using 3D printing as a tool to foster engagement and learning for the "net generation," in both K-12 and post-secondary settings.[1] At the same time, they expressed reservations due to the limitations posed by the exorbitant costs associated with 3D printing technology in 2005. Since then, costs associated with 3D printing have fallen dramatically. This is due, in large part, to the expiration of a number of patents in 2014 which has allowed a variety of new machines to be produced and marketed to non-commercial users.[2] Because of this, there have been a proliferation of efforts to use 3D printing as an engagement and outreach tool in formal and informal educational settings. Despite its potential as an innovative learning technology, Ryan and Grubbs noted that many articles show 3D printing in libraries as a "fun" or "creative initiative" rather than being fully integrated into the curriculum.[3] This perception is slowly changing as more and more academic campuses across the world are incorporating 3D printing in academic libraries, often under the broader umbrella of a makerspace, and publishing the models and methods they have developed for integration into and the support of teaching, learning, and research.

The University of Nevada-Reno's DeLaMare Science & Engineering Library is arguably the first academic library to offer 3D printing as a service in 2012.[4] Colegrove, the library's director, noted that the addition of 3D printing was a "natural fit with other visual resources" in the library, and provided equal access for everyone in the campus community because of its longer operating hours.[5] At the same time, Grand Valley State University's Mary Idema Pew Library was moving forward with its own 3D printing initiative while arguing for greater academic library support of the broader makerspace movement. Fisher argued libraries can "support and expand opportunities for hands-on experimentation and learning" because they are open to all campus constituents, provide convenient access, and often "strive to be the intellectual hub of campus – a place where students, faculty and staff from all disciplines can gather to explore, create and gain new knowledge."[6] Lankes concurred by writing:

> Because that is the core of the library – not the collection – idea creation and knowledge generation. Those books and stacks, and printers, and bathrooms, and study rooms and tape players and microfiche readers are just tools to get at what librarians are really supposed to be doing […] helping the community create knowledge and know itself.[7]

Since 2012, according to a map constructed by the Library Information Technology Association's (LITA) 3D Printing Special Interest Group, at least 117 academic libraries in the United States offer 3D printing services at the time of this writing.[8] While it is difficult to determine how many academic libraries house a 3D printer today because there is no central directory, the authors believe this number to be a rather conservative estimate.

Most librarians and authors take an idealized stance when answering the question, "Why the library?" Britton summarized what the Fayetteville (NY) Free Library, one of the first public libraries in the United States to offer 3D printing, went through to develop their 3D printing and makerspace services organically, and suggested the efforts were a natural extension of a library's services. She stated, "It is our job to create access and develop an environment where people can come together to share resources (whether they be physical or mental), collaborate, and create."[9] Griffey noted that libraries have, for decades, "adopted the role of providing universal access to technology", especially technologies that are "too expensive for the average person to own, but they are a potentially transformative technology that the public needs to be aware of."[10] By extension, Nowlan argued, efforts to provide access to technology should also include the development of digital and technological literacies.[11] Other academic libraries have reported on the use of 3D printing services as an effective way to advance outreach, teaching, and research programs,[12,13] promote knowledge sharing, innovation, and cross-disciplinary research collaborations,[14,15,16,17] or as a marketing tool to attract more users to the library which can make them aware of other library services.[18,19] No matter the reason for implementation, 3D printing services are an effective engagement and outreach tool which shows the academic library is constantly and actively engaged with its community, willing to meet the changing needs of its patrons, and could potentially break down artificial barriers erected between disciplines.

While most authors focus on the positives of implementing these services, the challenges seem to receive scant attention. Bharti detailed the challenges and lessons learned when the Marston Science Library at the University of Florida started their 3D printing service. She noticed many

of those challenges stemmed from, "stress[ing] to patrons, especially ones new to 3D printing, is that not all 3D models are suitable for printing."[20] At Southern Illinois University-Edwardsville's Lovejoy Library, Pryor described their experience with a 3D printing service as a "mixed bag."[21] In its initial year of offering a 3D printing service, Lovejoy Library saw widespread excitement and discussion about the potential uses of the technology from students, faculty and staff, but usage numbers were low. Pryor also noted a few theories that could explain this disassociation, and may include a lack of access to 3D modeling software or familiarity with the creation of 3D models, patrons simply being unaware of 3D model repositories with ready to print objects on the internet, or that the campus community had yet to grasp how 3D printing technology can be useful in scholarship, research, other creative activities, and learning.

Challenges to implementing the service and making it successful may also originate with library personnel as well. Gutsche[22] offered advice on how to train and empower library staff and volunteers when faced with new, unfamiliar technology. In expressing the limitations of the patrons' skills using the 3D printing facility, she stated, "3D printers are super fun, but without the design skills and software required to put them to practical use, I see them being of limited value to public libraries….Making meaningful use of this technology is no small project." Others have also noted the importance of staff training and professional development[23] and the core competencies[24] library staff need to effectively manage the technology, space and services provided. While not explicitly stated within the literature cited above, it could easily be argued that the more familiar library personnel are with the technology, the services provided, and its potential applications the more likely staff are to talk about it with patrons.

The next section of the paper covers the background and initial collaborative efforts. This is followed by a description of the makerspace lab at the library, resources and components that have been developed, and workshops and feedback of the participants. Conclusions and future work are covered last.

Background

Academic libraries, more and more frequently referred to as an information or learning commons, are arguably the most accessible facilities on a college or university campus. Most are open longer than any other building on campus and some are accessible 24 hours a day five days a week during the academic year. Logic, as does practice, suggests that a campus library would be one of the better places to house equipment intended to improve accessibility to 3D printing and provide students with an informal workspace to extend their learning beyond the classroom. With this in mind, the College of Engineering and Technology's Department of Technology Systems approached the main campus library in the spring of 2014 with the hope of forming a partnership to make 3D printing more accessible to the campus community to house a 3D printer in the library in order to make the technology more accessible to the campus community. See Figure 1. Following the meeting, which included the director of the campus' main library and select library staff members, it was agreed that a small study room within the library would be made available to the authors, and converted to house the 3D printer.[25]

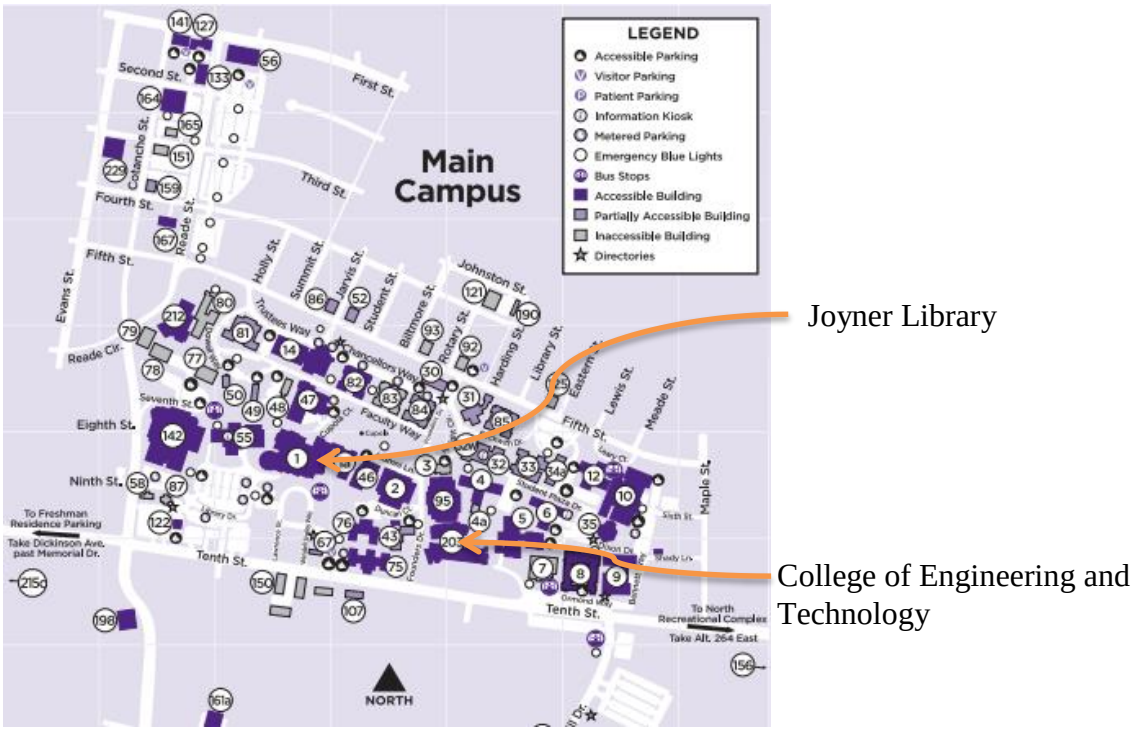


Figure 1. Campus map depicting the location of key structures.

In the fall of 2014, an industrial grade 3D printing system was deployed to Joyner Library and library personnel were trained on the system. Since then, various initiatives have been undertaken to broaden the 3D printing technology knowledge base within the campus community and increase its accessibility for use. Two additional 3D printers were added to the stable in the last year and more library personnel have been allocated and trained to implement and promote this initiative. Web resources have been published for educating, training, and automating processes to shorten the learning curve effectively lowering barriers to entry and making 3D printing resources more accessible. "Introduction to 3D Printing" workshops have been offered to all faculty, students and staff within the campus community to improve their understanding of the software, hardware and process of 3D printing. While the time devoted to training varies, all training is lab-based and hands-on. Workshop participants have come from a diverse array of disciplines within the natural sciences, health sciences, humanities, and the social sciences. Faculty members from different colleges, departments, and disciplines have brought their classes to the library so their students can explore 3D printing technology. In less than a year, this initiative has grown and become a full-fledged campus wide endeavor with more growth expected. To sustain this growth, and ensure its long term viability, grant and other funding opportunities are being sought. The initiative's next step is to support interested faculty with the integration of 3D printing technology into course assignments and projects and to foster multidisciplinary research and other creative activities.

Figure 2 depicts the location of Joyner Library's three 3D printers on the 2nd floor of the Library. The 3D printers include the ZPrinter® 310 Plus, which was introduced to the market in 2005, and is an entry-level, powder based, 300x450 dpi resolution 3D printer.[26] It resides in a small, converted study room. Figures 3(a) and 3(b) show the signage above the door of the room, and

the newly installed machine. In addition to housing a portion of the library's general stacks and the industrial grade 3D printer, the second floor is also home to the Library's Teaching Resource Center (TRC). The TRC is a curriculum materials center whose mission is to directly support the teaching and learning of students, faculty and staff in the College of Education as well as educators of all levels throughout eastern North Carolina. Because of its mission, and the explosion of 3D printers being purchased by K-12 schools in eastern North Carolina, two more hobbyist, tabletop 3D printers were installed in the TRC's Ann Rhem Schwarzmann Production Center in the fall of 2015. Despite its focus on serving pre- and in-service educators, the Production Center is open to the entire campus community, including science, engineering and technology students.

Figure 2. Second floor plan of the library with the location of the 3D printers identified.

(a) (b)

Figure 3. Collaborative 3D printer lab and equipment.

Low-Tech Makerspace in the Library

Originally christened as the "Enhancing Teachers Classrooms" (ETC) Room when it was first built, the TRC's Production Center is considered a low-tech makerspace. It was designed to assist pre-service teachers in the creation and preparation of materials they can use during their practicum assignments, teaching internship and in their own classroom upon graduation. The room is outfitted with two lamination machines, over 800 Ellison die cuts, a comb binder, two button makers, a large format poster printer, computers with educational software, an award

maker and a vinyl letter cutter.[27] Many K-12 educators throughout eastern North Carolina also use the Production Center throughout the year. Over the years, these tools have assisted hundreds of students and area educators in the development of unit lesson plans, classroom decorations, and presentations. As an incentive to use these services, the TRC offers all students, faculty and staff on campus 10 free feet of lamination, five buttons and five comb binders each semester. These services have proven to be extremely popular with internal statistics showing the Production Center has been visited by over 7800 students, faculty, staff and area educators since the beginning of the 2014/2015 academic year.

Because of its visibility, active patron base, a renewed focus on science, technology, engineering and math (STEM) education, and the proliferation of 3D printing in K-12 schools across the country, the library's administration decided to equip the Production Center with two hobbyist level 3D printers in the summer of 2015. This initiative was meant to test the waters and gauge the campus community's response while the TRC researched the feasibility of creating a more modern makerspace to support the University's teaching and learning missions. After three months of experimentation, drafting policies (See Appendix A) and procedures (See Appendix B), and creating web-based resources for the campus community,[28] the 3D printing service debuted on October 1, 2015. The remainder of the fall semester was treated as a "soft opening" for the service with marketing and outreach focused toward students, faculty and staff within the College of Education and the College of Engineering and Technology.

In addition to the ZPrinter, a FlashForge Creator Pro[29] was chosen to be stationed in the TRC. The FlashForge Creator Pro uses a fused deposition modeling (FDM) method, has a dual extrusion head allowing interlaced color objects to be printed, and can extrude acrylonitrile butadiene styrene (ABS), polylactic acid (PLA), nylon, and even composite materials such as wood and metal filaments. It was chosen for its versatility, and product research showed it would give interested library staff and patrons the opportunity to "tinker" with the printer to improve print quality. The Library also purchased a Lulzbot Taz 5[30] single extrusion, FDM machine with the expectation patron demand would require a second printer. The Lulzbot was chosen for similar reasons as the FlashForge as it provides the same versatility in the types of filaments that can be used, and is generally considered an intermediate level 3D printer where additional "tinkering" would be needed to produce high quality prints.

The collage in Figure 4 shows the computer and 3D printer setup within the Teaching Resources Center and shows one of the authors, who is affiliated with the TRC, delivering 3D printing instruction to students from the College of Engineering and Technology. This instruction session was scheduled as a direct result of the Library's initial marketing and outreach efforts after the 3D printing service debuted.

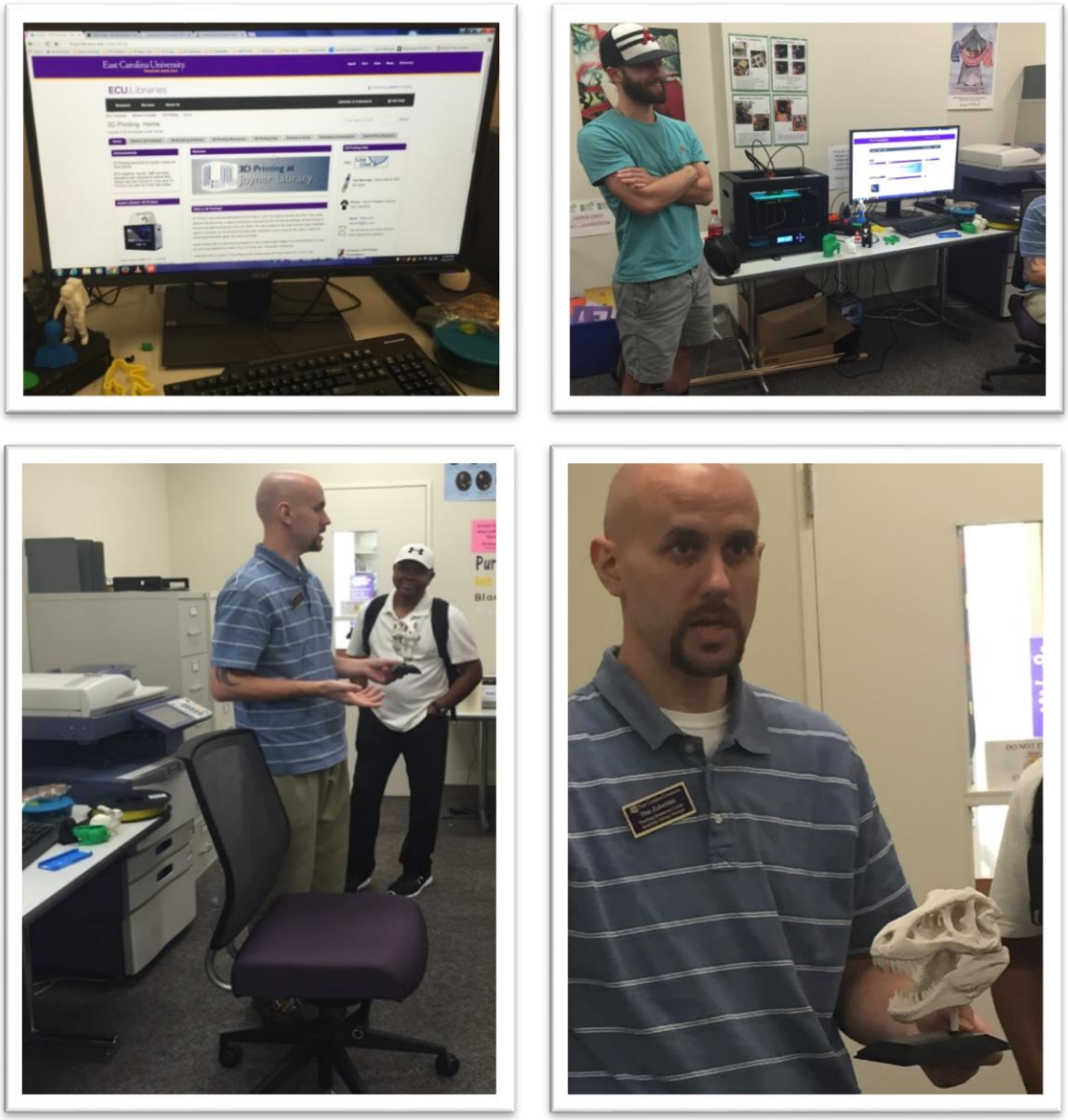


Figure 4. 3D printer setup in the Ann Rhem Schwarzmann Production Center and snapshots of an instruction session.

In preparation for the official launch of the Library's 3D printing service, one of the authors, who works in the TRC, created a libguide as a reference resource to be published on the Library's webpage. See Figure 5. The purpose of this resource is to inform the campus community of the two types of 3D printers the Library supports (FDM and binder jetting), introduce patrons to a variety of free 3D modeling software and internet resources, offer tips and tricks to help solve common 3D modeling problems that may result in poor print quality and outline the service's policies and costs. While a unique email address was created for the service, 3dprinting@ecu.edu, the libguide serves as the main conduit to the web-based consultation request (See Figure 6) and print request forms (See Figure 7) to centralize and streamline the processes for both services.

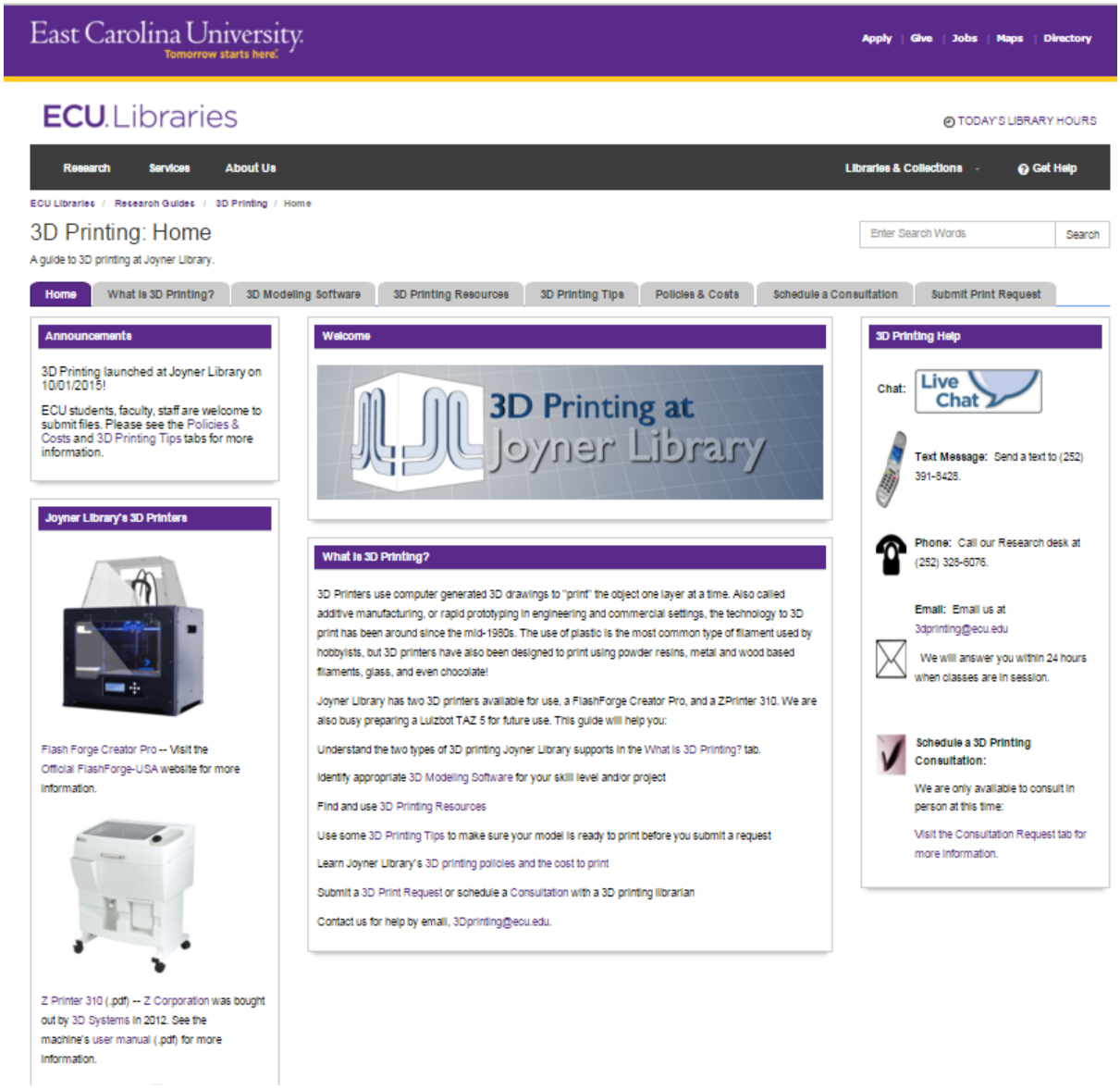


Figure 5. Front page of Joyner Library's 3D printing libguide.

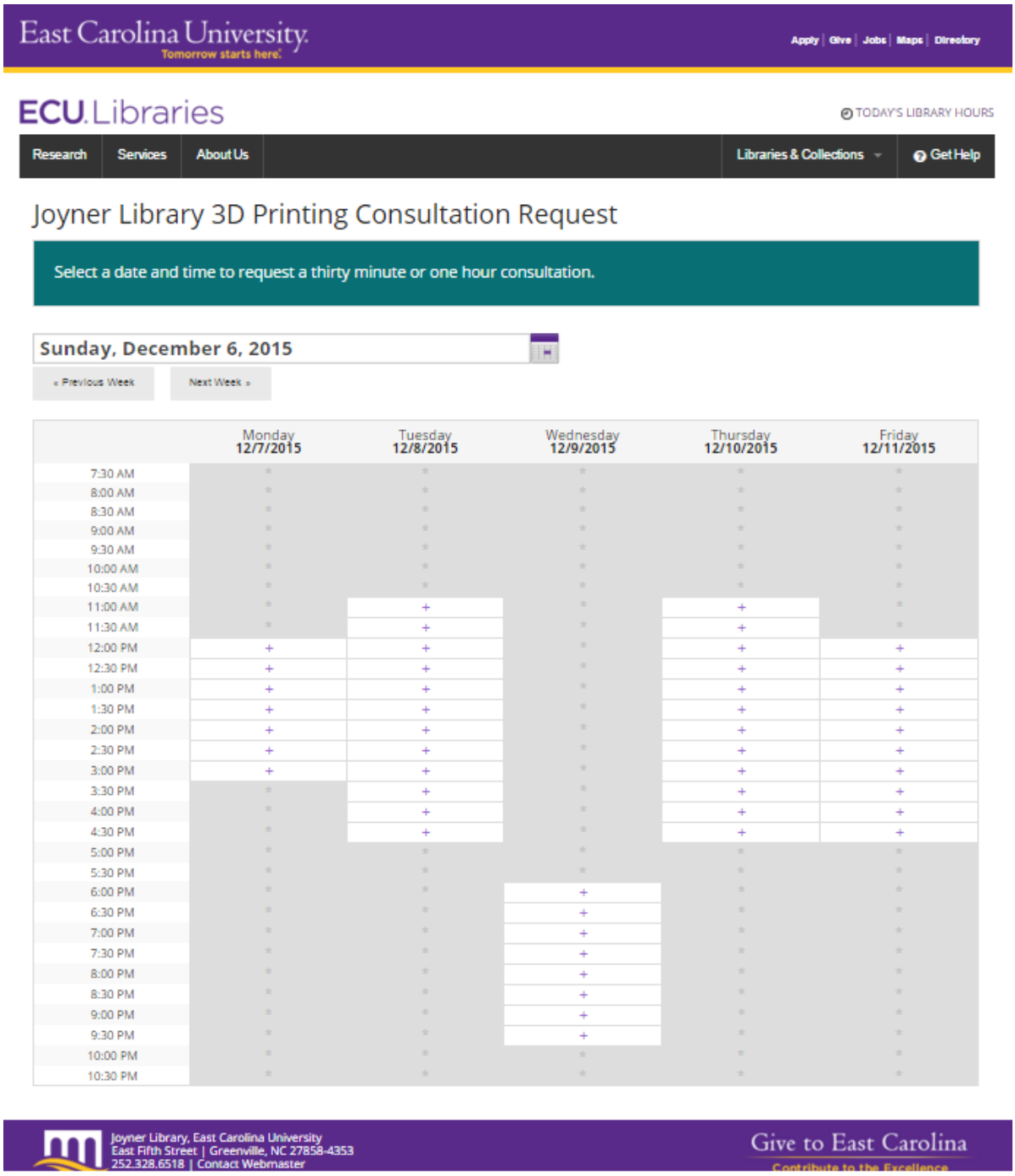


Figure 6. Joyner Library's online 3D Printing Consultation Request page.

The Library believes offering 3D printing consultations is an important part of the overall service. After attending an "Introduction to 3D Printing" workshop, patrons are encouraged to schedule a consultation to learn more about the process of 3D printing, obtain more specific training on the Library's 3D printers and 3D modeling software, or to talk through any potential design issues that could result in a failed print or poor print quality. Patrons do not need to have a

finished product in mind when scheduling a consultation, only an interest to engage with the technology.

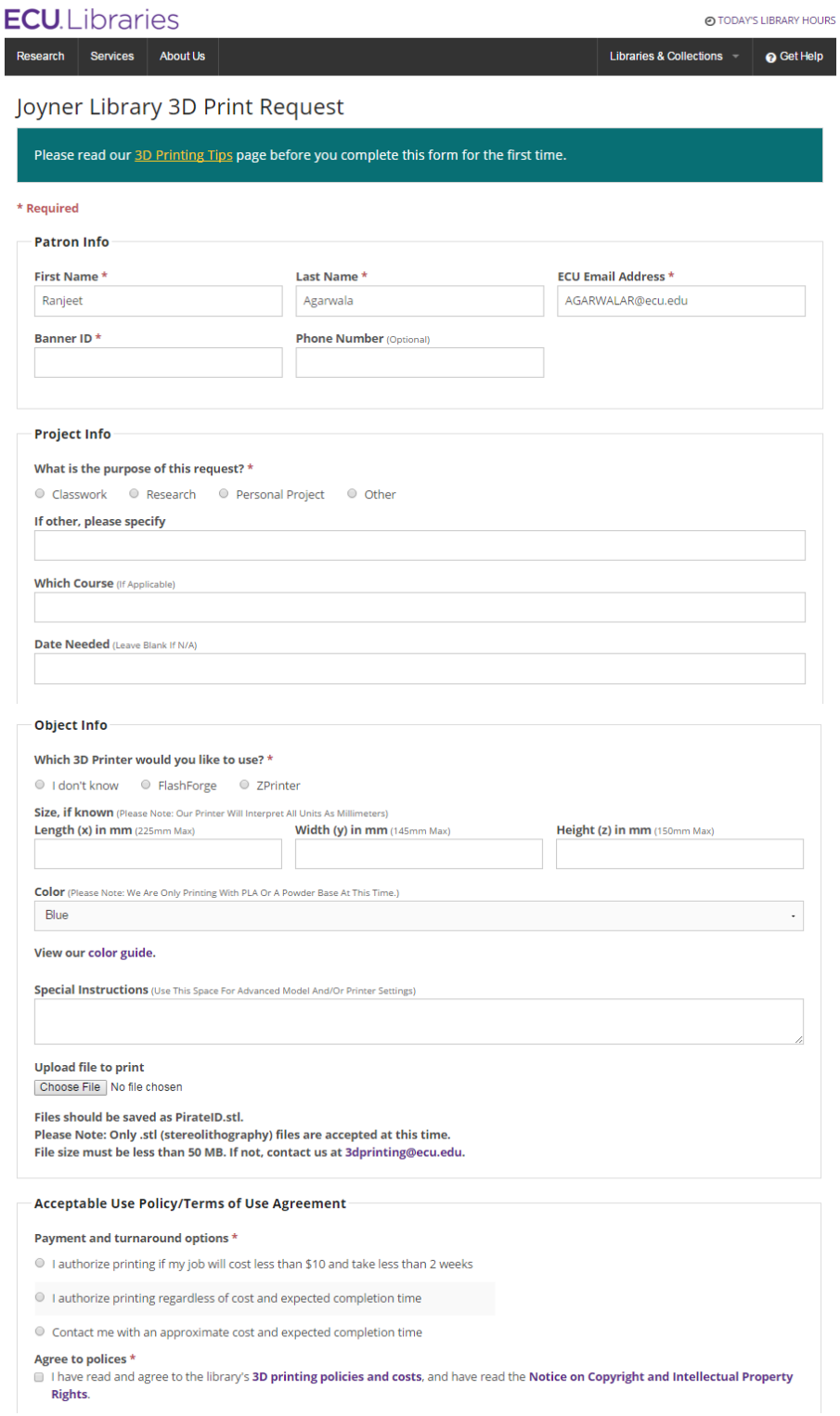


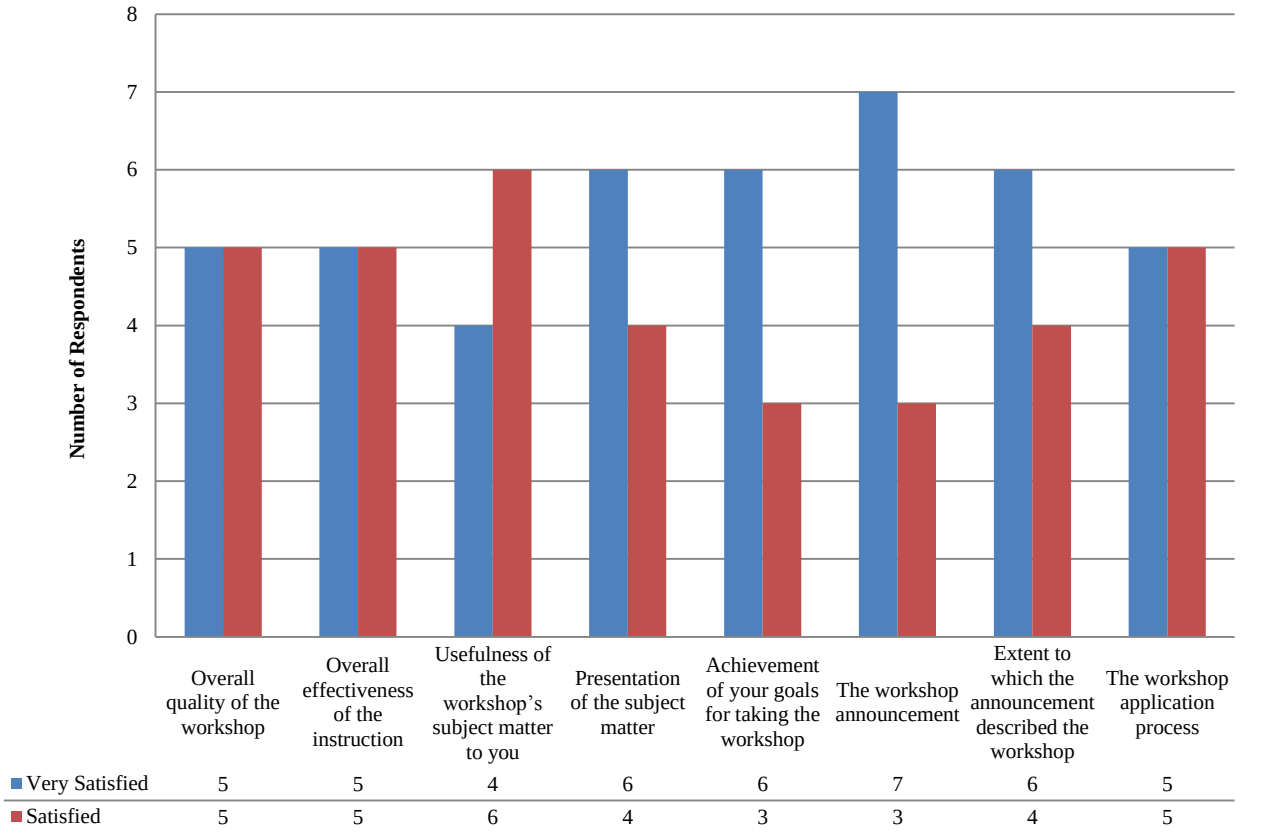
Figure 7. Joyner Library's online 3D Print request page.

Workshops and Participant Responses

The first "Intro to 3D Printing" workshop was facilitated by one of the authors, a faculty member in the College of Engineering and Technology, in December 2014. The workshop was conducted to provide ten library staff members with an overview of 3D printing and the collaborative effort between Joyner Library and the College of Engineering and Technology. A short post-workshop survey was administered to participants to gauge their satisfaction with the workshop. Generally speaking, all participants were satisfied with their workshop experience. The summary data are depicted in Figure 8 and participants' feedback can be found in Appendix C.

Comments on the post workshop survey included the following:

- "More organized presentation. think about attending a larger workshop"
- "I would like to go to advanced workshop. I think I wanted a more in-depth(probably the one offered over a few day period)"
- "Yes, I would like to attend an advanced workshop"
- "Very interesting, would like to be contacted about the next date workshop id available.
- "Interested in attending Summer Workshop"
- "Can't wait for the next step!"
- "interested in attending advanced workshop"



Scale: Very Satisfied, 4; Satisfied, 3; Dissatisfied, 2; Very Dissatisfied, 1.

Figure 8: Level of satisfaction with the 1-hour workshop.

Beginning in October 2015, when the 3D printing service debuted, and ending in April 2016, another 10 "Intro to 3D Printing" workshops were facilitated for 123 students, faculty and staff. Just like the initial workshop, participants came from a diverse variety of disciplines. Disciplines represented included Biology, Anthropology, Economics, Dental Medicine, Bariatric Medicine, Art & Special Education, Manuscripts & Rare Books, Sociology, Mathematics and Foreign Languages. These workshops were approximately an hour long, taught by Joyner Library faculty and staff, and used the 3D printing libguide as a reference as the instructor engaged attendees with examples of completed and failed prints throughout the first half of the session. With a 3D printer printing in the front corner of the room, attendees learned about the two types of 3D printing the Library offers, the differences between PLA and ABS thermoplastics, the various types of 3D modeling software, and current and potential uses in industry and academia. The last half of the session was reserved to teach attendees how to design their own small part, a one inch cube with a hole in it, using the beginner level 3D modeling program Tinkercad. After each session, it was not unusual for attendees to stay and ask the instructor additional questions. Most of these extended question and answer sessions lasted one half hour or more.

Similar to Southern Illinois University-Edwardsville's Lovejoy Library, Joyner Library's experience implementing a 3D printing service has been a "mixed bag." As a result of the fall semester's workshops, faculty members in Special Education, Nutrition Science, Art, and Business requested 3D printing demonstrations for their spring courses. New opportunities to collaborate with the Department of Biology to print replacement bones for their anatomy and physiology labs, the University's Office of Facilities Engineering & Architectural Services to print their own architectural models, and the Department of Kinesiology to print customized laboratory equipment have presented themselves. As a group, students in the College of Engineering and Technology have made the most use of the service comprising 21% of the total number of print requests submitted and approximately 17% of all consultation requests. All but one of these students were working on personal projects, rather than required coursework, and have submitted at least one additional print request. The three engineering students who scheduled consultations did so because they had yet to be exposed to a 3D printer in their coursework, and ultimately submitted a print request for a personal project. The increased access to 3D printing technology in Joyner Library has also encouraged a handful of students in the College of Engineering and Technology to create a Pirate Maker Club which is actively recruiting new members, and hopes to have an organizational meeting in the near future.

The spring 2016 semester was also used to increase awareness of the service through brief articles published in the Joyner Library and TRC's e-newsletters, a glass display case complete with 3D printed models in a high traffic area on the first floor of the Library, and a 3D printed version of the board game *Settlers of Catan* was used during the Library's "Game Night" in April. The TRC also hosted two events showcasing one of the 3D printers in the main lobby of the Library on Sunday evenings, when the Library generates its highest gate count for the week. In addition, specialized workshops that focused on the applications of 3D printing in the health professions, arts and humanities, social sciences, and math and science were marketed to faculty who were interested in integrating 3D printing into their courses for the 2016/2017 academic year. These workshops were well attended as 24 graduate students and faculty attended the math and science, arts and humanities and health professions sessions while the social sciences session was cancelled because no one registered. Additional workshops for faculty in the same discipline

categories are being planned for the fall, but with the intent of taking a 3D printer "on the road" and meeting with faculty in their respective departments and buildings across campus.

Despite the overwhelmingly positive response to the "Introduction to 3D Printing" workshops, from engineering students, and the number of times the 3D printing libguide has been viewed (3,736 views in seven months) the number of total print and consultation requests have been low compared to ECU's potential user base, approximately 21,000 students who attend classes on campus. The 89 total print requests from 43 unique users and 18 total consultation requests are also considered low when compared to more established 3D printing services at other academic libraries, but they are comparable to the first year statistics of at least one other academic library.[31] It must be noted that a faculty member teaching an elementary education science methods course required his students to create or modify and 3D print a functional doorstop for a class project for the spring 2016 semester. This assignment accounted for 17 print requests (19% of the total) and eight consultations (44%). Potential reasons are still under evaluation, but the low use of the service could be attributed to any number of variables including the lack of access to 3D modeling software or familiarity with the creation of 3D models, the cost of printing an object, or patrons simply being unaware of the dozens of 3D model repositories with ready to print Creative Commons licensed objects on the web (e.g., Thingiverse, 3D Warehouse, Yeggi, etc.). Admittedly, 3D printing has been slow to catch on outside of traditional STEM disciplines so it is quite possible students and faculty have not yet been able to imagine how 3D printing may be used in teaching and learning, scholarship, research, or other creative activities within their discipline.

The authors are hopeful the broader marketing campaign and additional workshops this spring will encourage more use of the service. Additional plans are also being made for the fall 2016 semester to offer a broader array of educational programming. But, if the elementary education science methods class offers any insight into the future use of Joyner Library's 3D printing service, it is that 3D printing must be integrated into the curriculum, or be a required feature of a course project, for most students to utilize the service until they become more familiar with the technology. This echoes Ryan and Grubbs' concern that 3D printing in libraries will only be a "fun" or "creative initiative" until 3D printing is integrated into the curriculum.[32] To this end, increasing the educational component of the service will also complement the work of the faculty and staff from Joyner Library, the College of Engineering and Technology and the College of Education who are working on several grants to secure local, state, and federal funding to sustain and grow this initiative and develop best educational practices and research.

Conclusions

Many academic campuses across the nation and the world are increasingly incorporating 3D printing in their academic libraries. In this paper, the authors reported on an example of a regional public doctoral university incorporating 3D printing in their main campus library and the associated educational components, methods and best practices. Resources published for educating, training, and automating and in general improving access to the 3D printing resources for library patrons and other users have been discussed. 3D printing workshops were offered to campus community members to improve their understanding of 3D printing technology. Since its inception, the initiative has grown and become a campus wide endeavor with more growth

expected in the future. Faculty members from different colleges, departments, and disciplines have scheduled 3D printing demonstrations so their classes can explore 3D printing technology, and students in the College of Engineering and Technology have also been direct beneficiaries of the new service because they are now able to develop and print personal projects they did not have the opportunity to print before. The endeavor's next steps are to expand the service's marketing campaign, offer additional educational programming, and meet directly with faculty who may be interested in integrating 3D printing into course assignments. It is hoped that the methods adopted by the authors' academic library may be adopted at other academic settings in the nation and the world.

Acknowledgement

The authors wish to thank Mr. Hayden Holleman. Mr. Holleman is a B.S. in Design student in the College of Engineering and Technology at East Carolina University, and helps run the 3D printers at Joyner Library in support of this initiative.

References

1. Ramaley, J. A., and Zia, L. (2005). *The real versus the possible: Closing the gaps in engagement and learning*. Retrieved from http://www.educause.edu/research-and-publications/books/educating-net-generation/real-versus-possible-closing-gaps-engagement-and-learning
2. Hornick, J. & Roland, D. (2013, December 29). *Many 3D printing patents are expiring soon: Here's a roundup & review of them*. Retrieved from http://3dprintingindustry.com/2013/12/29/many-3d-printing-patents-expiring-soon-heres-round-overview/
3. Ryan, S.M & Grubbs, W.T. (2014). Collaboration in support of 3D printing as an emerging technology in academic libraries. *Florida Libraries*, *57*(2), 11-16.
4. Free, D. (2012). University of Nevada-Reno library offers 3-D printing. *College & Research Libraries News, 73*(8), 455.
5. Colegrove, P. (2014). Making it real: 3D printing as a library service. *Educause Review Online.* Retrieved from *http://www.educause.edu/ero/article/making-it-real-3d-printing-library-service*
6. Fisher, E. (2012, November 28). Makerspaces move into academic libraries. *ACRL TechConnect Blog*. Retrieved from http://acrl.ala.org/techconnect/post/makerspaces-move-into-academic-libraries
7. Lankes, R. (2013). *Beyond the bullet points: missing the point and 3D printing*. [Web log]. Retrieved from http://quartz.syr.edu/blog/?p=2538
8. Goodman, A. (n.d.) Map of 3D printers in libraries. [Web log]. Retrieved from http://www.amandagoodman.com/3D/
9. Britton, L. (2012). A fabulous laboratory: The makerspace at Fayetteville Free Library. *Public Libraries, 51*(4), 30-33.
10. Griffey, J. (2012). Absolutely fab-ulous. *Library Technology Reports*, *48*(3), 21-24.
11. Nowlan, G.A. (2015). Developing and implementing 3D printing services in an academic library. *Library Hi Tech*, *33*(4), 472-479.
12. Scalfani, V. F. and Sahib, J. (2013) A model for managing 3D printing services in academic libraries. *Issues in Science and Technology Librarianship*. Retrieved from http://www.istl.org/13-spring/refereed1.html
13. Colegrove, P. (2014). Making It Real: 3D Printing as a Library Service. *Educause Review Online.* Retrieved from *http://www.educause.edu/ero/article/making-it-real-3d-printing-library-service*
14. Groenendyk, M. & Gallant, R. (2013). 3D printing and scanning at the Dalhousie university libraries: A pilot project. *Library Hi Tech*, *31*(1), 34-41.
15. Hoy, M B. (2013). "3D printing: Making things at the library." *Medical reference services quarterly*. Retrieved from http://www.tandfonline.com/doi/abs/10.1080/02763869.2013.749139#.VM059C6gxdM

16. Phetteplace, E., Brooks, M., & Heller, M. (2013). Library Labs. *Reference & User Services Quarterly*, *52*(3), 186-190.
17. Massis, B. E. (2013). 3D printing and the library. *New Library World*, *114*(7/8), 351-354.
18. Gonzalez, S.R. & Bennett, D.B. (2014). Planning and implementing a 3D printing service in an academic library. *Issues in Science and Technology Librarianship*. Retrieved from http://istl.org/14-fall/refereed3.html
19. Brown, D. & Vecchione, A. (2014). How to pack a room: 3D printing at albertsons library. *Idaho Librarian*, *64*(2), 1.
20. Bharti, N., Gonzalez, S., & Buhler, A. (2015, January). 3D technology in libraries: Applications for teaching and research. In *Emerging Trends and Technologies in Libraries and Information Services (ETTLIS), 2015 4th International Symposium on* (pp. 161-166). IEEE.
21. Pryor, S. (2014). Implementing a 3D printing service in an academic library. *Journal of Library Administration*. *54*(1), 1-10.
22. Gutsche, B. (2013). Makerspaces in libraries: Patron's delight, staff's dread? *Alki*, *29*(1), 28-30.
23. Luthy, C. (2015). Making makers: Educating librarians about makerspaces. *Computers in Libraries*, *35*(9), 4-8.
24. Koh, K. & Abbas, J. (2015). Competencies for information professionals in learning labs and makerspaces. *Journal of Education for Library and Information Science*, *56*(2), 129.
25. Agarwala R., Chin R. A; Improving Accessibility to 3D Printing; Engineering Design Graphics Division, American Society of Engineering Education, IL, October 2014**.**
26. 3D Systems. (2005). *Z corporation raises 3D printing quality and affordability standard with zprinter 310 plus*. Retrieved from http://www.3dsystems.com/press-releases/z-corporationraises-3d-printing.
27. Teaching Resources Center. (n.d.). *TRC ann rhem schwarzmann production center*. Retrieved from http://www.ecu.edu/cs-lib/trc/productioncenter.cfm
28. Zuberbier, Daniel P. (2016). *3D printing*. Retrieved from http://libguides.ecu.edu/3dprinting.
29. FlashForge USA. (n.d.). *FlashForge creator pro dual extrusion 3D printer*. Retrieved from http://www.ff3dp.com/creator-pro-3d-printer.html
30. Lulzbot. (n.d.). *Lulzbot TAZ 5*. Retrieved from https://www.lulzbot.com/store/printers/lulzbot-taz-5
31. Pryor, S. (2014). Implementing a 3D printing service in an academic library. *Journal of Library Administration*. *54*(1), 1-10.
32. Ryan, S.M & Grubbs, W.T. (2014). Collaboration in support of 3D printing as an emerging technology in academic libraries. *Florida Libraries*, *57*(2), 11-16.

Appendix A
Joyner Library's 3D Printing Policy

Joyner Library 3D Printing Policy

Joyner Library's 3D printers are available to ECU students, faculty, staff (the "User") to make three-dimensional objects in plastic or powder resin using a design that is uploaded from a digital computer file. As a condition of using Joyner Library's 3D printers, Users agree to the following terms and conditions (the "Terms and Conditions"):

I. The Library's 3D printers may only be used to support ECU's teaching, research, and service missions. No one is permitted to create material that is:
    a. Prohibited by local, state, or federal law or violates ECU or University of North Carolina policies.
    b. A weapon or part of a weapon (Note: N.C. Gen. Stat. § 14-269.2 specifically prohibits weapons to be possessed or carried on campus.)
    c. Unsafe, harmful, dangerous, or poses an immediate threat to the well-being of others.
    d. A violation of another's intellectual property rights. User represents and warrants to ECU that the designs submitted are original to the User, in the public domain, or that the User otherwise has the legal right to use the design (for example, the user has obtained a license or permission to use the design from the rights holder). User shall be responsible for and shall hold ECU harmless for any claims or damages arising from or relating to User's violation of this representation and warranty or the Terms and Conditions.
    e. For commercial use.
II. The Library reserves the right to refuse any 3D print request for any reason.
III. Patrons may only submit **ONE** print request at a time. Additional requests should not be submitted until the previous request is finished.
    a. For multi-part models that will need to be assembled to create a single design when finished, email us for prior approval, or schedule a consultation.
    b. This service is designed for rapid prototyping, not production. No jobs printing large numbers of identical objects will be accepted.
IV. Joyner Library cannot guarantee model quality or stability, nor confidentiality of submitted designs. 3D printed items are provided to users "as is" and without warranty of any kind. Users are responsible for removing rafts and supports.
V. Items must be picked up by the individual who submitted them, using a valid ECU OneCard. Items not picked up within 30 days after being printed become the property of Joyner Library, and a fine will be assessed to your library account.
VI. Only designated Library employees will have hands-on access to the 3D printers at this time.

If you would like to meet with a library staff member for additional information about 3D printing you can schedule a consultation or email us your questions.

Appendix B
Joyner Library's 3D Printing Procedures

3D Printing Procedures

1. Print Request Received
2. Save file to Print Request Folder ion 3D printing folder on :J drive
    a. Change filename to studentID.stl, if necessary
3. Open file in Meshmixer or Simplify3D
    a. Determine Acceptability
        i. Copyright/IP/Trademark -- If issues, email patron rejecting request or asking for clarification
        ii. Appropriateness -- If issues, email patron rejecting request
        iii. Ask patron to provide proof of ownership, public domain, for class project, etc., if necessary
        iv. Acceptable -- Proceed to Step 3b
    b. Check for design errors
        i. Major errors -- email patron describing issues and wait for corrected file
        ii. Minor errors -- Fix and proceed to Step 4
4. Open file in Simplify3D, document the following:
    a. Estimated print time
    b. Weight in grams
5. Email patron file is accepted
    a. $10/2wks -- inform patron of estimates and request is added to print queue
    b. Regardless -- inform patron of estimates and request is added to print queue
    c. Contact -- inform patron of estimates and request is added to "pending" sheet
        i. Once confirmed patron data is moved from "pending" to print queue
6. Input Data into appropriate Google Sheet
7. Move .stl file to appropriate folder in 3D Printing folder on shared drive
8. Once file is at top of queue, open in Simplify3D and print
9. When print is finished, email patron it is ready for pick up. Notify of any changes in weight, and quote price.
10. Complete "invoice" and place with print in staging area at service desk
11. Patron arrives at TRC Service Desk
12. Weigh object in front of patron
13. Patron takes "invoice" to Circulation and pays for print
14. Patron returns to TRC with receipt and receives their print
15. Patron goes home happy
16. TRC Staff staples invoice and receipt together and places on top shelf of 3D Printing supply cabinet

Appendix C
Selected Feedback of Workshop Participants

College/Department/ Center -- (OPTIONAL)	What additional 3D Printing training you need for your discipline or area?	The actions you will take in the next 90 days (~12 weeks) to apply what you've learned:	What you liked best about the workshop:	The most useful tips, techniques, or skills you're taking away from this workshop:
Management		Try to fit/create it into my spring syllabus.	Informational and hands on.	Getting more comfortable with the resources and software.
University Printing & Graphics	I have a pretty good basic understanding of 3D rendering software. I just need more practice utilizing tutorials and projects to increase my knowledge of advanced features.	I plan on investigating the various free 3D programs available to see what will be the best option for learning more advanced functions of this type of software	Getting to see the 3D printers in action. I have seen many videos but they do not compare to seeing it firsthand. Although very basic, I enjoyed starting to use Solid Works.	The basic functions of Solid Works.
CFAC/SOAD/Art Ed	Pedagogy. Workflow for large numbers of students. K-12 art education best practices.	Design project for art ed undergrads to try next semester.	Broad range of topics covered.	How to export file in universally-understood format.
Dean of Students Office	I presently have no needs, but wanted to learn more for my own knowledge.	I will pick up my cube as soon as the current weather situation subsides.	I enjoyed learning about the variety of software and practical applications that 3D printing has.	Walking the class through the software was very helpful.
BSOM/Clinical Simulation Center	Interested in creating organ systems and organ for clinical simulation for medical student, residents and faculty staff.	not sure at this time	Hands on portion	the programs to utilize for building out prints
Planning	I would like to learn how I can enlist help in developing *.stl files for 3d printings of buildings from Madrid, Spain, either from photos, or from help from architecture/engineering etc.		practical side	practical file construction
Biology			The clarity and pace...perfect.	We have the support to do what we want with this technique.
Dept. of admissions		Will try to learn more about "Blender" 3D creation suite	Hands-on	Working knowledge of "SolidWorks" and the actual printing demo.