Maximizing STEM Education Initiatives on a Minimized Library Budget

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Abstract

This article provides practical suggestions for creating opportunities for Science, Technology, Engineering, and Mathematics (STEM) education partnerships and programming, despite the funding struggles of many academic libraries. With pressures from internal and external funding avenues, academic libraries must create an environment where libraries and librarians reach out in order to encourage buy in for library programs, services, and support. Using the book budget cuts and serial subscription reconfiguration at the University Libraries of the University of Memphis as a jumping off point, this article explores creative but necessary strategies for connecting with students, faculty, librarians and others engaged in STEM education. The creation of the Center for Research and Innovation for STEM Teaching and Learning (CRISTAL) at the University of Memphis presented a critical opportunity for engagement with the libraries. Points of discussion include how the University Libraries became involved with CRISTAL, the ways the CRISTAL has driven its engagement with our University Libraries, resources implemented to broaden the impact of this relationship, literature supporting the methods used, opportunities related to such collaborations, and plans moving forward. This article also includes suggestions for how such opportunities might present, and might be embraced, at other institutions.

KEYWORDS: STEM education, library outreach, science librarianship, funding, community engagement, Next Generation Science Standards, NGSS, Common Core, academic librarianship

Introduction

Like many libraries across the United States, the University of Memphis University Libraries has had financial challenges. Despite universities spending more than ever—Association of Research Libraries (ARL) reports that institutional spending stands at around 3.5 times what it was in the 1980s—institutional libraries have been living on smaller and smaller portions of that pie (Kolowich, 2012). The Association of Southeastern Research Libraries' (ASERL) Fall 2011 Statistical Index (ASERL, 2012) indicates an average total library expenditure of $19.3 million that year. The University of Memphis was dead last at $8.9 million. Things improved slightly in 2012, when the University of Memphis rose two notches, becoming the third lowest in funding—but the average ASERL library expenditure for that year had also risen by $5 million (ASERL, 2013). While our ranking may have improved that may be more indicative of the financial difficulties affecting other member libraries than of any improvement in circumstances at the University of Memphis. By ASERL standards, members should have annual library expenditures of half the member average, after discarding the highest and lowest numbers. The University of Memphis stood at $3 million short.

At least partly due to underfunding, academic departments have struggled to keep a positive image of the University Libraries, and its personnel. This quickly became apparent when we have been unable to subscribe to critical (very expensive) databases or periodicals and/or acquire titles of great interest. Underfunding has impacted our collection's ability to stay current and meet faculty needs. Many libraries share our experience of having to review their materials, (severely) tighten purse strings, and apologize a bit too often because their current level of funding hinders their ability to

accomplish mission objectives, such as remaining current and embracing research faculty collection needs (Ragains, 2012).

Our Science, Technology, Engineering, and Mathematics (STEM) students and faculty, for whom databases, e-journals, expensive textbooks, and current materials are so critical, represented a community we knew we wanted to reach in a new way. We asked ourselves: What *can* we do? How can academic librarians at a research university best serve as liaisons to these departments, especially when library funds toward these departments are especially limited? How can we make the most of our librarian skill sets, without drawing attention to our funding issues?

Low Cost, High Impact Initiatives

Relationships between academic libraries and academic departments suffer when library budgets suffer. As the higher education financial rollercoaster continues, we need to find new strategies. By thinking outside our usual dynamics with University departments and our typical liaison responsibilities (purchasing for the collection, subscribing to new serial titles, adding databases, etc.), we find opportunities to change our dynamics completely, and for the better.

Fortunately for the University Libraries, a new initiative recently began on campus: our Center for Research and Innovation for STEM Teaching and Learning (CRISTAL). As an interdisciplinary effort, the Center for Research and Innovation in STEM Teaching and Learning isn't just about the knowledge of STEM subject areas. It's about supporting our programs, making local and regional connections, connecting projects with funding sources. Perhaps most critically for the Libraries, the CRISTAL is also about connecting faculty with "University resources for the reform of classroom

instruction" (Center for Research and Innovation in STEM Teaching and Learning, 2013). These reforms include: online, blended, and flipped instruction initiatives; asynchronous and synchronous distance education; and research experience for undergraduates. Since librarians have experience in these areas, this establishes a natural point of collaboration.

CRISTAL membership is open to all University of Memphis faculty and professional staff who share an interest in STEM Teaching and Learning and all are encouraged to apply. Three librarians requested and received CRISTAL membership in Fall 2012 and they represent the University Libraries as liaisons to the fields of Engineering, Chemistry, Biology, Mathematics, and Physics; a fourth applied and was added in Fall 2013, connecting CRISTAL to our Management and Information Sciences, Decision Sciences, and Mechanical Engineering liaison. Several other librarians have participated in CRISTAL functions but have not pursued CRISTAL membership. When attending CRISTAL functions, we can each speak to our own skills and track records with student development. By presenting ourselves to STEM faculty in a new setting, in a different context, we hope to change their perspective on our work and our value.

Our goals are simple:

- Have a library presence at the CRISTAL events.

- Network, network, network – let our faculty engage with us in a new setting and generate new discussions.

- Listen for opportunities – find new involvements and initiatives.

- Be listed as members of the CRISTAL on their website.

- See what happens!

Thus far, CRISTAL has hosted STEM networking mixers for students ("STEMixers"), seminars for STEM/CRISTAL faculty ("STEMinars"), a Memphis STEM Leadership Academy, and other events, including grant collaboration workshops for CRISTAL members. STEMixers focus on building a student community particularly for undergraduates across STEM disciplines, creating a fun environment for students, and encouraging faculty members and students to interact outside the classroom setting. STEMinars have the greatest attendance from faculty and typically occur following a STEMixer, facilitating faculty attendance at both events. This piggy backing of events allows for a valuable differentiation in content; STEMixers provides to students the valuable, but hard to find, time to socialize with faculty in an environment of interest to both groups (and with food!), whereas STEMinars allow faculty critical opportunities for professional development through a common interest group setting and using content of interest to STEM educators. Targeting faculty growth could be as simple as a presentation by an instructional design professor or watching a relevant video and discussing afterwards. A recent video the CRISTAL showcased was Dr. Treisman's Plenary Speech at the Science and Technology Education Partnership (STEP) 2013 Annual Meeting, entitled "Innovation as Ornament and the Challenge of Improvement at Scale (Find out the latest in what needs to occur in STEM Education and possible solutions)" (ASEE_DC, 2013).

In the past year that librarians have been members, the relationship has already proven very worthwhile. In one of the first STEMinars CRISTAL hosted, members shared their interests in CRISTAL and talked about their work. One faculty member mentioned an upcoming *FIRST*® LEGO® League (http://www.firstlegoleague.org/)

competition, the first time this event would be held at the University. This event focuses on exciting nine to fourteen year olds in the greater Memphis region about science and LEGOs, teamwork and values, and important social issues.

The social issue for *FIRST*® LEGO® League 2012 was SENIOR SOLUTIONS℠. By requiring each team of 9-to-14 year old competitors to talk to the elderly, to understand their struggles and health issues, these teams worked to research and develop innovative means to improve the circumstances of the elderly. As a faculty member within the Libraries and as a student in University of Memphis's School of Public Health, one librarian at the meeting offered to help as a judge. Organizers welcomed her participation and just that quickly the Libraries had found a way to be an active presence at the event. This fall, *FIRST*® LEGO® League teams will tackle the 2013 NATURE'S FURY℠ Challenge. The librarian has been asked back as a judge. Our Emerging Technologies Librarian has been encouraged to participate in judging the robotics portion. Organizers now see our librarians as reliable and useful resources contributing to the overall success of the day-long event.

In general, at CRISTAL's events, librarians have been able to better connect with both undergraduate and graduate students in STEM fields. Often, students have approached us with questions about the resources we mention, including citation management tools like RefWorks, databases for research in their discipline, and our LibGuides. Additionally, faculty members have grown more comfortable discussing perceived student needs with librarians in this more relaxed setting. They have acknowledged weaknesses they frequently see within their students and have shown increased interest in connecting with the Libraries faculty to gain assistance for their

students. As a result, we were invited to speak at a STEMixer Spring 2012 and asked to design another STEMixer (which draws 15-100 undergraduate students from all STEM disciplines) as well as a STEMinar for faculty for Fall 2013.

Ragains (2012) states, "Many academic libraries are seeking more instructional involvement as an important means of articulating their service mission" (p. 140). Three important factors come into play when planning instruction for our CRISTAL students:

1. Students often don't know what they don't know, but often perceive that they know more than research would indicate they do (Bandyopadhyay, 2013).

2. STEM faculty members do not routinely pursue librarian visits to their classrooms (Leckie & Fullerton, 1999).

3. CRISTAL students meet *outside* the classroom and out-of-class learning can be deemed particularly valuable by STEM undergraduates (Thiry, Laursen, & Hunter, 2011).

Using these factors as a framework, we can strategically develop targeted or atypical library instruction sessions designed to increase academic performance and graduate school preparedness for multiple student levels and STEM disciplines. Additionally, these sessions can inspire competitiveness for internships, co-operative work experience, and potentially lead to increased options for their future employability. We needed to take the opportunity to reach STEM students and STEM faculty *outside* the classroom setting and maximize the perceived value of library engagement and library resources, including librarians.

The Fall 2013 STEMinar brought roughly twenty-five students into the primary, computer-equipped instruction classroom of the University Libraries, as well as a few

CRISTAL "chaperones." Three librarians were present, though one served as the primary instructor for the session. Research by Huizenga, Admiraal, Akkerman, and Dam (2009) and Francis (2012) discusses the wealth of ways to motivate the engagement of individuals, including options within library instruction settings. The former notes curiosity, fantasy, and recognition as means for motivation (Huizenga, Admiraal, Akkerman, and Dam, 2009); the latter draws a parallel from fantasy to humor and also touches on group work and games as strategies for generating sustainable enthusiasm (Francis, 2012).

With this in mind, the instruction librarian made humorous comments ("I know Prof. Ivey offered extra credit for this, but I know that's not why most of you are here. Cathy [the Associate Director of CRISTAL] is handing out candy. That's why I'm here, too.") and prompted participation ("Who knows PEMDAS? What does the 'P' stand for? What do you think happens if I search: (bioluminescence OR chemiluminescence) AND 'living organisms'?"). By and large, both strategies achieved success with this group of students. Francis (2012) cites research establishing the fact that humor can increase content retention, perception of learning, and creativity, as well as relieve stress and build classroom rapport (p. 154). Success was evident in the questions students asked ("Can we use RefWorks for group projects, too?"; "Wait—you'll get me articles from stuff we don't subscribe to for free…as PDFs?!") and in their delight when realizing that their background and interests in STEM had already taught them a bit about searching (computing logic; database building; order of operations).

Student feedback was particularly valuable and also hinted at the successfulness of the session. They requested a post-instruction tip sheet to help them further retain the

information from the session (see "October 4, 2013 - Library Resources for STEM Education at the U of M" at http://memphis.edu/cristal/ steminar_presentations.php to access the handout developed after the session) and that such sessions be held *each* semester ("Why am I a fifth year Senior and only learning this *now*?"). Research by Voelker (2006), Willis and Thomas (2006), Kasperek, Johnson, Fotta, and Craig (2007), Griffin and Ramachandran (2010), and Thorne and Williams (2012) supports the power of extracurricular engagement with students as a useful alternative to and/or enhancement of one-shot instruction in specific courses (intercurricular instruction). Scholarship has also established "friends" as a popular source of information for college students regarding everyday life research (Head & Eisenberg, 2009). Having these students in a cohort based on overlapping extracurricular interests (rather than in a course-specific setting) worked in our favor with regard to their attentiveness and overall engagement.

The faculty STEMinar had quite different content. Resources like LibGuides (http://libguides.memphis.edu/ResearchGuides, including our STEM Education subject guide) and databases such as SpringerLink and Web of Science (and Journal Citation Reports) were discussed in terms of their ability to aid in faculty research. Faculty found this session conducive to their questions about particular citation styles, toward what resources they might point their students, how they might coach new additions to their department on the use of our scholarly resources, and so forth. While this STEMinar was not incredibly well-attended (eight faculty were present), those in attendance came from several STEM disciplines as well as from our TIGERS Teach program (see http://www.memphis.edu/tigersteach/about.php), which enables students to pursue a secondary education teaching certification while working toward their bachelor's degree

as part of a five-year program. Faculty who attended felt more well-informed about library resources, librarian engagement with their work, and even made suggestions about additional useful features we could add to our research guides, including linking various newsletters.

In addition to the main content we wished to deliver, we sought to highlight the fact that developing relationships between CRISTAL and the University Libraries can and should feed and inform the research efforts within their scholarship as well as ours and make contributions to scholarship *outside* library science (McKnight, 2010; Dilevko, Allison-Cassin, Aspinall, & Mauro, 2006). The faculty STEMinar became an appropriate setting to emphasize the fact that, as faculty, librarians also actively engage in research and, in this case, our research displays our investment in and our mission to support STEM student and faculty scholarship. Dr. Pam Dennis, the primary instruction librarian at our STEMinar session with faculty, had given a STEM-related poster session at ALA Annual 2013 (see http://ala13.ala.org/m/node/12061). Now on display in the University Libraries conference room, the poster focused on STEM collaborations with public, school, and academic libraries as well as the use of library resources by STEM faculty at the University of Memphis when doing research for publication over the past five years. Her poster also shows our interest in identifying which resources faculty use for scholarship and understanding how they interact with resources for which we do, or do not, have subscriptions.

We also believe the interdisciplinary publication and grant writing opportunities exist, though we are only beginning to explore these options. As interest in STEM education continues to grow, and as STEM education conferences develop, librarians

would be wise to pursue opportunities to write *with*, present *alongside*, and stand *among* STEM educators in professional settings. Kennedy and Brancolini (2012) quote from Rebecca Watson-Boone's (2000) article when they write, "Many academic librarians become practitioner-researchers, defined as professionals who 'approach projects and problems in ways that yield (1) solutions, (2) an enlarged understanding of their actual field of work—their *practice*, and (3) improvements in practice" (p. 433 of Kennedy & Brancolini; p. 85 of Watson-Boone). Librarians can bring a problem-solving mentality, a curious nature, and skills as practitioner-researchers to their engagement with STEM faculty.

Using that problem-solving mentality, as a result of the faculty STEMinar, we are now in the preliminary stages of developing L^AT_EX (http://latex-project.org/) workshops that should benefit upper-level undergraduates in capstone projects and graduate program preparedness, establish library-driven support for graduate and doctoral candidate use of this documentation program, and alleviate some of the pressure felt by STEM faculty to support this tool. The University Libraries hopes to host its first L^AT_EX workshops, appropriately targeted toward our STEM constituents, in Spring 2014. This will build on the work of Georgia Tech (http://www.library.gatech.edu/ calendar/libclasses.php), the Stevens Institute of Technology (http://stevenslibrary.blogspot.com/ 2010/11/library-workshop-wednesday-november-10.html), the University of Cincinnati (http://guides.libraries.uc.edu/ceasworkshops), and others and enable us to become a campus support for this popular typesetting system.

Librarians Are Not Book Jockeys

The CRISTAL's focus on teaching and learning as well as its interdisciplinary

nature has opened the doors for our Libraries to collaborate with STEM faculty on STEM instruction. In the seemingly ever-growing inundation of information in our lives, it becomes critical that we ask a question posited by Leckie and Fullerton (1999), "Where will future working scientists and engineers develop the fundamental information literacy skills they will need on the job?" (p. 10). Given the fact that many scientists rely on their personal collections and colleagues in the field for information, we can hardly expect current undergraduates or prospective students to have these networks and sources at the ready. Leckie and Fullerton (1999) go on to highlight the likelihood of students in science disciplines using only textbooks for at least their first two years of study. As a result, these students often do not have the opportunity to develop skills related to information retrieval and research paper writing until very late in their undergraduate career—or even as late as graduate school (p. 11). Harvey (2012), Pritchard (2010), and Petzold, Winterman, and Montooth (2010) draw attention to this lack contact between science students and librarians within all stages of their science education. CRISTAL seizes the opportunity to bring science students into the fold as a way to bridge the gap between professional development and STEM coursework, and it frequently pursues the University Libraries as a collaborator in that effort.

As instruction tactics for STEM education shift and change through new faculty hires, flipped classroom initiatives, and funding options—as K-12 education transitions towards the Common Core and the Next Generation Sciences Standards (or NGSS)—we can find openings for the Libraries to participate at the ground level of these exciting conversations within our academic community (Common Core State Standards Initiative, 2013; Next Generation Science Standards, 2013a). Looking forward, understanding the

trends in STEM education, such as the NGSS, will be important for academic libraries to grasp. If students are learning differently in their K-12 academic careers, they're going to learn differently in their postsecondary academic careers, too. Just as we currently see altered student experience and preparation due to the impacts of No Child Left Behind, this "next generation" approach to science education enlightens us regarding what the next group of students might bring to the table. Like CRISTAL, NGSS focuses on the experience of learning (and teaching) science as well as the very important need to build and strengthen our future workforce. Librarians engaged in information literacy instruction and in critical thinking skills development can appreciate and stand behind these goals.

As members of CRISTAL, the librarians have attended discussions of these standards and their potential and immediately felt a connection to their "crosscutting concepts," which can be implemented to learn patterns, cause and effect, and connections to other fields (Next Generation Science Standards, 2013b). Examples of these concepts include:

- Science knowledge indicates what can happen in natural systems—not what should happen. The latter involves ethics, values, and human decisions about knowledge. (HS-PS3-f)
- Many decisions are not made using science alone, but rely on social and cultural contexts to resolve issues. (HS-PS3-f)
- New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. (HS-ESS3-f)

- Scientific knowledge is a result of human endeavors, imagination, and creativity. (HS-ESS1-f)

If we had not joined CRISTAL, the University Libraries may not have heard about NGSS as quickly, nor in as relevant a context, and perhaps would not have taken the time to delve into its implications for our future students. In being present for these conversations and meetings, we can discuss NGSS with our STEM faculty. We could also use it to generate discussion about information literacy objectives and STEM competencies within institutional curricula, building on Scaramozzino's research (2010). We are finding that it is just as important to meet our faculty where they are as it has been to meet our students where they are.

Don't Reinvent the Wheel—Use the Wheel

CRISTAL members, including librarians, have come to realize we've been putting our own separate efforts into supporting our local school system. While we try not to reinvent the wheel, we have not been coordinating our efforts or being particularly inclusive of each other either.

The STEM-focused efforts of teaching and learning facilitated by CRISTAL members will have a different style in that they take place outside the traditional classroom, course-focused environment. They create a popular extracurricular setting geared toward increasing student success and interest in STEM disciplines. A true partnership means that we can all play a part in facilitating success and engagement. What can the STEM education community offer these students? How can we reach and better prepare potential future students of the University of Memphis?

Working with STEM faculty to market STEM engagement and campus support

networks to prospective students and local K-12 partners, the University Libraries can provide:

- Library instruction with in-library access to our databases and resources
- A jumpstart on understanding conducting scholarly research (Warren & Duckett, 2010)
- Community borrowing privileges for our collections
- Increased confidence in the ability to accomplish college-level assignments
- Vital encouragement to pursue their STEM interests
- Assessments of scientific knowledge using instructional software (e.g., Clickers or Google Forms)
- A University of Memphis network of potential mentors

Know Your Customer

Finding new avenues to connect with STEM faculty is exciting, and the partnership between CRISTAL and the University Libraries continuously generates new bonds and innovative efforts. Learning that the "meet them where they are" approach works for both students *and faculty* is invaluable. The needs and activities of STEM students and faculty often differ from their counterparts in the humanities and social sciences and librarians should use that knowledge wisely.

While the humanities and social sciences often integrate research papers into coursework, STEM students are far more accustomed to the scientific method and experimentation, and high research failure rates (Krebs, 2012). STEM students may also be involved with grants, conferences, and awards-pursuits. When creating research

guides for STEM subjects, librarians must keep these important distinctions in mind.
Guide features to consider:

- Grant writing/research proposal resources

- Tools for writing scientific research papers/articles

- Information on prizes and awards in that discipline or field

- Tips for using field-specific databases such as saved searches, alerts, etc.

- Adding a STEM faculty member to the guide as a collaborator

As STEM teaching and learning studies become increasingly interesting to
faculty, research guides can integrate STEM teaching and learning resources, too. Guide
features to consider:

- Their CRISTAL equivalent and/or similar centers at other institutions
  (e.g., CRSTL at Oklahoma State University)

- NGSS links/information

- Access to the *Journal of STEM Education Innovation & Research*

- Links to conference information in the field (e.g., Georgia Southern
  University's Scholarship of STEM Teaching and Learning Conference)

- Information on innovative STEM partnerships, resources and institutes
  (e.g., the Entrepreneurial Leadership in STEM Teaching and Learning, or
  EnLiST, and the STEM Education Resource Center available through PBS
  Teachers)

Librarians can find relevant research guides for more ideas and may even consider a

research guide or subject guide specifically on STEM teaching and learning (University of Wisconsin-Madison Libraries, 2012).

When STEM faculty learn your guides have integrated STEM teaching and learning, and/or you've created a guide devoted entirely to STEM teaching and learning, they may desire to provide links to these guides from their individual websites, department sites, etc. Just by pitching the idea, librarians show they want to align their efforts and to assist with the goals of the STEM faculty. Such conversations enable STEM faculty to participate and become more invested in the work of the library and its librarians, without focusing on funding.

At the graduate level, STEM students at the University of Memphis often come from outside the United States. International students have needs that differ from other students for a variety of reasons (Amsberry, 2008). Culturally, legally, and academically, international students seek, use, and think about resources in ways unique to them. If an institution sees many international students in its STEM ranks, STEM faculty and the University Libraries must work to develop a better understanding of this constituency and how to best serve them.

Reading relevant literature about STEM fields and library science proves helpful in learning about the various STEM student populations and in developing creative education initiatives for them. These articles may focus on instructional technologies or collaborative efforts, or they may address different factions of the STEM student and faculty community, or information literacy initiatives directed toward STEM subjects. They all make clear the fact that librarians have a wealth of options to pursue with their STEM departments, and it's truly a matter of developing the "right" partnerships and

collaborations, and perhaps finding a scenario or effort to model, suitable for your community that makes all the difference.

Other Low Cost, High Impact Options

Not all liaison assignments link librarians and their academic background. For librarians who have an undergraduate or graduate degree in a STEM subject, it may be worth pursuing professional membership(s) in STEM-related associations instead of, or in addition to, professional membership(s) in the field of librarianship. For example, a librarian liaising with Chemistry might benefit from joining the American Chemical Society (ACS, 2013). If membership is not an option—perhaps you don't have the academic background or it is cost prohibitive—exploring the professional societies of your STEM subject can still be enlightening. (It's worth knowing that such memberships are typically tax deductible: http://www.irs.gov/ publications/p529/ar02.html).

The ACS website, for example, includes:

- Educational resources from elementary school through the graduate level
- Standards and guidelines for Chemistry programs
- An Emerging Science section (e.g., Green Chemistry)
- Information on their outreach efforts, such as National Chemistry Week

Exploring is free and provides librarians with topics for discussion and networking, as well as grounding in Chemistry education standards and perhaps even insights based on new areas of research in the field. Librarians can integrate this knowledge in the classroom when designing searches, encountering course assignments, and preparing students for their field of choice, at the university and beyond.

STEM teaching and learning conferences exist and, as STEM liaison librarians often instruct sessions within their disciplines, librarians may want to think about potential collaborations with STEM faculty for conferences or presentations (Georgia Southern University, 2013). Not all faculty members will express interest in collaborating with librarians in such ventures but, if you find one that does, much potential exists to draw positive attention to the work of both STEM faculty and librarianship. Where tenure is a factor, publications and conference presentations will benefit all team members. Given the information overload and time limitations that faculty often suffer, partnering for publication or presentation offers opportunities to share in effort and accountability toward achieving scholarly goals. Such interdisciplinary collaborations could also work toward creating broader audiences for one's scholarship. A librarian publishing with an Education or Communications faculty member in a publication from one of those fields would reach an audience that an article in the *Journal of Academic Librarianship* might not; a Chemistry professor publishing with a librarian in a library journal would highlight the work of the Chemist in a unique way.

Another way to increase library/STEM faculty partnership is through the grant writing process. If library collections are underfunded or lacking in certain STEM areas, librarians should investigate grants that may allow for collection building purchases while also making provisions for STEM faculty, such as an upcoming outreach program they have been planning. Encouraging those at the table to consider whether the library might help author the proposal or be integrated into the program that the grant would support can bear fruit in the long run and prove quite worthwhile. In some instances, having a librarian as a Principal Investigator (PI) or co-PI for a grant might be

advantageous, too. Grants for 3D printing and maker spaces, for example, are ripe for collaborations between academic libraries and, say, Engineering faculty—and perhaps Art, medical school, and law school faculty as well—to pursue funding to purchase such technology and open up use and campus discussions about these emergent technologies. For those interested in collaborating in grants, the most critical components may be open ears and a seat at the table. As our relationship has developed, CRISTAL leadership has stated an interest in working with the University Libraries on grants to pursue mutually beneficial opportunities (e.g., summer bridge programs for area high school students supported by CRISTAL and the University Libraries) as well as grants to support the collaborative efforts in which we have already begun to engage (e.g., pursuing funding for a makerspace within McWherter Library).

Next Steps

Now that we have had our first full-fledged STEMinar with STEM faculty, the time is ripe to pursue embedded relationships within upper-level undergraduate courses, such as Research Methods, as well as Professional Development courses at the graduate level. We should also investigate how librarians might better engage with faculty in the STEM disciplines using a flipped classroom and/or project-/problem-based learning approaches. Workshops targeted to the needs of STEM students and faculty, focused on particular skills (e.g. those in development regarding L^AT_EX), will create additional opportunities for STEM faculty and students to bond, and for the Libraries to be seen as a conduit for that interaction. Other workshops under construction focus on conducting literature reviews and writing for the sciences; creating annotated bibliographies within RefWorks; resource sharing tools for research teams; and infographics creation, best

practices, and their application in the sciences.

Our Instructional Services Librarian and our Emerging Technologies Librarian are both interested in bringing STEM students into relevant University Libraries projects as well. Ever want a robot to scan shelves to find out-of-order titles? Want patron-built apps for your libraries? Thinking that having students help oversee a 3D printing lab might be both convenient and resource savvy? Such ventures would be advantageous to both groups. Librarians can find the extra hands, the tech-savvy entrepreneurial spirits, and the student-driven enhancements on the path toward establishing an exciting 21st century academic library environment. In return, students receive opportunities they can highlight on resumes, note in graduate school applications, and use to develop and hone their skills to better prepare for their future within their intended science field, including Information Science! To this end, our Emerging Technologies Librarian has become co-advisor to a new student group on campus that is interested in maker spaces and the Instructional Services Librarian will be involved in discussions about creating and helping to advise a student organization for women in STEM.

Many of the suggestions for maximizing STEM education initiatives in this article revolve around the need for conversations. Remember: conversation is free. Become a part of your campus's (or other local) equivalent of CRISTAL, bring these strategies into your interactions with your STEM faculty, and keep your finger on the pulse of STEM teaching and learning. By doing so, you can help change and broaden the perception of what libraries (and librarians) engage in as highly trained, knowledgeable, service-driven individuals. Academic librarians can bring a valuable perspective to the STEM teaching and learning conversations. We can also provide a surprising amount of that at very little

to no cost—and the benefits will outweigh what little cost there may be.

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