Maker Competencies and the Undergraduate Curriculum

Abstract

How might academic library makerspaces impact undergraduate student learning? This is the question that The University of Texas at Arlington (UTA) Libraries, in collaboration with University of Nevada–Reno's (UNR) DeLaMare Science and Engineering Library want to answer by exploring best practices that incorporate cross-disciplinary, transferrable ("transdisciplinary"), maker-based competencies into the undergraduate curriculum.

To this end, we are requesting $49,800 from IMLS in the form of a National Leadership Grants for Libraries Planning Grant in the Community Anchors project category. A Community Anchors Grant is relevant to our work because academic library makerspaces are uniquely situated as anchors for interdisciplinary teaching and learning within the academic community. We routinely collaborate with faculty representing a cross-section of academic disciplines and we provide discipline-neutral spaces and services that encourage interdisciplinary collaboration among students. Using grant funds from IMLS, we will demonstrate the feasibility of anchoring the academic library makerspace into the undergraduate curriculum, so that students from a variety of disciplines may acquire highly-sought transdisciplinary skills. While this planning grant will help us develop and refine our maker-literacies programs locally, we will continue to expand on the work done here to develop nationally recognized and accepted maker literacy standards, much like the Association for College and Research Libraries' (ACRL) Information Literacy Competency Standards became best practices for academic libraries around the nation.

UTA and UNR Libraries have already begun exploring competencies that can be acquired in our makerspaces, and with other institutional partners (yet to be selected), we will use this grant to develop evidence-based best-practices for incorporating measurable maker-based competencies into the undergraduate curriculum. The findings from our work will also be applicable beyond the undergraduate curriculum and academe in general; UNR being a land-grant institution with outreach responsibilities to the greater-Nevada community, can take what we've learned from this study and explore ways to incorporate maker-based competencies into community programming.

Success will be determined by completion of pilot programs that allow us to test and improve our early-stage set of maker-based competencies and develop best-practices for assessing student learning of the those competencies. Upon the completion of this pilot study, we will submit an application for an IMLS Project Grant in order to broaden our impact and advance national practice.

Maker Competencies and the Undergraduate Curriculum

1. Statement of National Need

The National Association of Colleges and Employers (NACE) Job Outlook 2016 reports that American companies seek employees with transdisciplinary skills, listing the attributes: ability to work in teams, communication (verbal and written), problem-solving, analytical/quantitative reasoning, initiative, flexibility/adaptability, work ethic, organizational ability, strategic planning, creativity, and entrepreneurship/risk taking as highly-sought skills among new hires. The same survey suggests that a bachelor's degree is the preferred degree for a majority of positions that employers seek to fill. Employers are not always successful at finding applicants with both a subject-based bachelor's degree and the listed transdisciplinary skills.

Academic library makerspaces are uniquely suited to fill this pedagogical gap by fostering cross-disciplinary, hands-on experiential learning opportunities that can be scaffolded into the undergraduate curriculum. Results of a 2013 Library Research Service survey indicated that 41% of respondent libraries currently provided maker-related activities and an additional 36% intended to begin doing so in the near future. Many of these library makerspaces were created to address transferable, cross-disciplinary skills such as critical and creative thinking, research skills (beyond Google), project planning and management, professional communication, the ability to work in multidisciplinary teams, and adaptability to new contexts and circumstances. These spaces foster student innovation and entrepreneurship, allow for creation of new knowledge objects, and provide active learning spaces outside the classroom. They often gain support from faculty looking for avenues for their students to access new technologies. Clearly, academic library makerspaces provide opportunities for students to gain competency in the same transdisciplinary skills outlined by NACE.

Maker Education

Dewey's (1938) theory of learning argues that we construct knowledge through evaluation of experience paired with existing knowledge. Constructivism has informed educational practice for decades, resulting in pedagogical approaches such as constructionism, problem and inquiry-based learning, guided instruction, and cooperative learning. Design thinking, a constructivist approach to problem solving, is an iterative cycle of problem identification, research and knowledge sharing, creative ideation to solve the problem, prototyping, testing, and evaluation (Design Thinking for Educators, n.d.). Making, potentially paired with the design thinking process, are poised to be the next pedagogical expression of constructivist theory. Although makerspaces have become fairly ubiquitous in K-12 settings, public libraries, museums, and on college and university campuses, educators have yet to provide substantive practical tools that allow the measurement of student learning that results specifically from making.

[Note: References in the above literature review and throughout this document are listed in Supportingdoc1.pdf.]

There have been a few explorations of the general learning that occurs in makerspaces (Sheridan, Litts, Brahms, Jacobs-Priebe, & Owens, 2014; Litts, 2015), but little has been done tying student learning in makerspaces to subject-based learning outcomes or measuring student learning in these areas. The literature is overwhelmingly devoted to K-12 learning. The debate that often arises when discussing the educational mission of makerspaces revolves around whether assigning and assessing the learning that occurs negates the self-directed, informal, and serendipitous nature of learning through making (Kurti, Kurti, & Fleming, 2014). Contrary to these concerns, maker-based curriculum has relevance throughout academia when considering transdisciplinary skills—for example, the ability to manage projects or work in interdisciplinary teams. Spending on makerspaces in universities without

mechanisms to measure their impact on student learning, including meeting subject-based learning outcomes and developing transferable skills, may not be sustainable. Adaptable, measurable maker-based competencies will help both faculty and students articulate the learning that results from work in these spaces and will help makerspaces demonstrate their return on investment (ROI) for their inclusion on campuses.

Currently, much of the research related to learning in makerspaces focuses on the affective domain rather than skills-based learning. Specifically, interviews with practitioners focused on K-12 populations provide anecdotal evidence that making positively impacts student's self-efficacy, agency, character, and ability to self-direct their learning (Clapp, Ross, Ryan, & Tishman, 2016; Oxman Ryan, Clapp, Ross, & Tishman, 2016). The development of maker-based competencies will allow educators to provide evidence of learning in both the affective and cognitive domain.

Competencies-Based Education Model

For decades, competency-based education (CBE) has been discussed as a solution to many of the challenges that face higher education. Its reemergence in the discourse of academe over the last few years has been in response to ever increasing tuition costs, a desire to offer students a quick path to degree completion, and public skepticism about the value of a college degree (Gallagher, 2014). In addition, the Obama administration and Department of Education have allowed 40 institutions to experiment with CBE (including the University of Texas System), forgoing some existing regulations related to federal financial aid, in an effort to determine the viability of CBE as a model for modern higher education (Fain, 2015; Competency-Based Education Network, 2017). Characteristics of CBE include the rigorous assessment of learning outcomes, advancement based on mastery of competencies, and learning that is personalized, measurable, and transferable (Sorenson Irvine & Kevan, 2016).

Academic libraries have used competencies as a mechanism to integrate and assess information literacy in discipline-based curricula for many years. Beginning in 2000 with the approval of the ACRL's Information Literacy Competency Standards for Higher Education, academic librarians used these competencies to articulate the relevance of information literacy to disciplinary learning goals. With this as a foundation, librarians everywhere have collaboratively developed curricula with subject faculty and assessed the transferable information literacy skills acquired by students. These well-articulated competencies functioned as a platform for library involvement in broader institutional planning efforts. Between 2004 and 2011, 18 colleges and universities accredited by the Southern Association of Colleges and Schools (SACS) selected information literacy as the foci of their Quality Enhancement Plans (QEP), a required plan to improve curricula and assess student learning. Over one hundred additional colleges and universities included student learning outcomes based on information literacy competencies in their QEPs (Harris, 2013).

As faculty and students began to express a need to better address data visualization, management, publishing, and analysis, academic librarians began to explore how to engage with members of our campuses not just as users of data, but also as creators and publishers of data. Since 2012, data-related services have been listed as one (or more) of the top trends in academic libraries (ACRL, 2017). For this reason, in 2011, IMLS funded a project led by librarians and faculty from the Universities of Michigan, Minnesota, Oregon, Cornell, and Purdue, focused on developing data information literacy competencies. Just as the Information Literacy Competency Standards had done, these data competencies, published in 2015, provide a foundation for librarians working with data intensive disciplines to develop programming, integrate into the curricula, and collaborate with subject faculty (Carlson & Johnston, 2015).

The New Media Consortium's (NMC) Horizon Reports have acknowledged makerspaces as a significant technological development for both academic and research libraries and higher education in general, recommending

them as a trend to adopt within the next three years (Johnson et al., 2016; Johnson, Adams Becker, Estrada, and Freeman, 2015). These reports also emphasize the importance of redesigning learning spaces, blending formal and informal learning, and rethinking the roles and skills of librarians, all aspirations that makerspaces help fulfill. Although ACRL's 2016 Top Trends in Academic Libraries does not explicitly mention making or maker-based competencies, it does discuss libraries increased focus on competencies, credentialing, and employers' desire for new graduates with transdisciplinary skills. Many academic libraries have chosen to develop maker-based spaces and services in an effort to help students develop these skills, but have yet to develop the foundational competencies that help us to connect and collaborate with disciplinary faculty and assess student learning, as we have done for both information and data information literacy; such a partnership with faculty is encouraged in ACRL's 2015 Environmental Scan. Similar to how academic libraries have been deploying information literacy initiatives across the curriculum, their makerspaces are now positioned to deploy maker literacy initiatives.

Making in Academic Libraries

While there is no definitive definition for a makerspace, it is essentially a combination of spaces, resources, and services which support the creation of new knowledge, most often in the form of physical objects. Makerspaces grew out of the DIY and hacker culture which placed emphasis on collaborative knowledge and resource sharing. Though the first makerspaces in libraries were often in public libraries, in recent years more academic libraries have begun incorporating makerspaces, or equipment and services often found in them, into their spaces and workflows. In comparison to more traditional library services, the literature on academic library makerspaces is sparse; but a growing number of authors have written case studies about implementing such spaces and resources into their academic libraries and some have conducted profession-wide surveys on the topic. A makerspace, like any library resource, is developed to meet the needs of the direct user population. This means no two makerspaces will look alike as they grow and change to support their particular users.

Some academic libraries are experimenting with pop-up makerspaces, proving that such spaces can be affordable, simple, and ephemeral. Such pop-up events include holiday card making and polynomiography (Lotts, 2015). Others have created mobile makerspaces, allowing resources to be made available across campuses which can encourage those in disciplines not usually associated with making to utilize it. For example, the MobileMaker at Elon University was designed in consultation with the Teaching and Learning Technologies department to help make writing more visible in all its forms and to see making as a part of the creative process. The MobileMaker is primarily available to those living in residence halls, giving them access to unique making and creative resources regardless of their major discipline (Reis, 2015).

Much of the literature on makerspaces in academic libraries focuses specifically on 3D printing. While makerspaces can certainly exist without high-end fabrication technologies, the focus of the literature seems to be to assist others in the practical aspects of offering such new technology-based resources and services through their own library's experiences (Pryor, 2014; Groenendyk & Gallant, 2013; Nowlan, 2015; Scalfani & Sahib, 2013; Gonzalez & Bennett, 2014). In 2015, the Primary Research Group published a report titled, "The Academic Library Use of 3D Printing," which discussed the results of a survey completed by 25 college libraries who were offering 3D printing resources and services. It discussed many aspects of providing 3D printing including funding, staffing, usage numbers, training, and other practical operation information (Primary Research Group, 2015). What is lacking in the discussion is whether or not libraries are expanding their services to create a full makerspaces, fostering knowledge creation beyond 3D-printed objects, or the impact these technologies have on learning.

Speaking specifically to makerspaces and not solely 3D printing, some surveys and case studies have been done to better understand why libraries are choosing to implement makerspaces, how they are choosing to support and staff those spaces, and what the outcomes have been (Moorefield-Lang, 2014; Moorefield-Lang, 2015). The results show

that while each space is unique in their mission, capabilities, and infrastructure, the majority have small staffs who have not received prior formal training on the equipment in their space; they often rely on volunteers, online tutorials, and their own curiosity and passion to learn the equipment and then share that knowledge with others. The scope of these studies does not include the impact maker activities may have on learning. The Association of Research Libraries' (ARL) 2015 SPEC Kit 348 perhaps proves to be most useful when trying to gauge the current status of makerspaces in academic libraries. 64 out of 124 member academic libraries responded to an ARL survey, 64% of respondents were currently providing makerspace services and resources and another 17% were planning to investigate incorporating such services in the future. Libraries are currently offering a wide range of services and resources including 3D printing, 3D modeling, 3D scanning, hand tools, electronics, visualization equipment, laser cutters, CNCs, drill presses, sewing machines, and even drones. The kit goes on to describe current practices in creating and maintaining makerspaces, staffing and funding, and challenges commonly encountered. Almost all the academic libraries supporting makerspaces offer, or plan to offer, technology training and skill-building sessions to support creation in these areas though nothing is discussed regarding integration with curriculum or campus learning goals. (Altman, Bernhardt, Horowitz, Lu, Shapiro, & Association of Research Libraries, 2016).

There is also little in the way of literature focusing on training and professional development opportunities for librarians with the exception of Williams and Folkman. They discuss their grant-funded project which created in-depth experiences and training opportunities with maker topics and technologies to University of North Carolina at Greensboro LIS students and library professionals in North Carolina. There were hands-on opportunities with makerspace services such as 3D modeling and circuit building. A culminating conference provided presentations on topics including makerspace management, outreach, creative events, and specific services, such as 3D scanning. (Williams & Folkman, 2016).

2. Project Design

UTA Libraries, working with a multidisciplinary team of faculty, have created an early-stage set of maker-based competencies (see Supportingdoc2.pdf) that can be mapped to subject-based learning outcomes. This was done in-part by reviewing the literature on teaching and learning in makerspaces, in-part by interviewing staff at numerous makerspaces across the Dallas-Fort Worth region, and in-part by observational research of users of those makerspaces. The goal of this research was to identify high-level, transdisciplinary skills that are taught and learned in makerspaces. Related skills were grouped together and the groups were established as competencies.

In fall 2016, UTA Libraries piloted this early-stage set of maker-based competencies in four courses that completed projects in the UTA FabLab: two English courses, one Industrial Engineering course, and one Fine Arts Studio course. In each of these courses, early-stage competencies were adapted and mapped to course or assignment learning outcomes. At the conclusion of the semester, student work was assessed to determine whether the learning outcomes were met. Participating subject faculty reported that student performance indicates target competencies were gained by students in the courses (See Supportingdoc3.pdf). Additional assessment of the program is currently underway, and we expect to have a better understanding of how the program affected student learning using the selected maker-based competencies when we complete our final evaluation in spring 2017.

Similarly, UNR Libraries currently works with faculty in a variety of disciplines to integrate maker-based projects into courses as opportunities for students to acquire new and non-traditional skills, as well as STEM and information literacies. This Planning Grant will fund the identification of three additional academic library makerspaces that are exploring similar programs and that are willing to become pilot test partners with UTA and UNR. With our partners, we will further test the effectiveness of our early-stage competencies and investigate methods to measure student learning.

Intended Audience

Although there is broad applicability for maker-based competencies across the domain of education, our primary audience for this pilot phase is academic librarians and subject faculty. The maker-based competencies will provide a framework for assessment of student learning that results from the integration of making and design thinking into curricula. Our intent is to test these competencies in a diverse cross-section of academic libraries, including colleges and universities with different campus sizes, student body demographics, educational missions, and makerspace sizes and equipment. Secondary audiences include makerspace staff and teachers in K-12 and other educational environments, public libraries integrating making into their programming, and members of the White House Nation of Makers. Upon actual implementation of this program as a full project (which is beyond the scope of this planning grant), undergraduate students from a wide cross-section of subject disciplines will be our ultimate audience, as they will be the ones benefitting most from competency acquisition gained in this program.

Our primary audience of academic librarians and subject faculty will benefit from this planning grant by gaining an understanding of how making and design thinking apply to their subject disciplines, and how to integrate makerspaces into their curricula. Additionally, our intended audience will learn more about curriculum design, mapping competencies to learning outcomes, and measuring student learning. A fringe benefit will be that librarians and subject faculty will collaborate in new and exciting ways that take seriously cross-disciplinary teamwork. Tenure-track librarians and subject faculty will be able to use this experience and any publications that result from it for their tenure review.

Partner Selection

In our search for potential partners, we will be looking for academic library makerspaces that show activity in the realm of incorporating their makerspaces into the curriculum, or offering their spaces as classrooms for undergraduate courses. We will use the following activities to identify potential partners.

UTA Libraries recently conducted a national survey about makerspace culture. While not designed specifically for this project, we were sure to include questions to help us identify academic libraries interested in integrating their makerspaces into undergraduate coursework. The survey was distributed to national lists such as Library Information Technology Association's (LITA) Maker Technology Interest Group, American Society for Engineering Education's (ASEE) Engineering Libraries Division, ACRL's Science & Technology Section, and the White House Nation of Makers. The survey was heavily promoted on social media to capture responses from potential responders not subscribed to these mailing lists. As of this writing, we have collected over 170 responses to the survey. We will use this data to help identify potential project partners.

In addition to survey data, we will perform a landscape analysis of existing academic library makerspaces based on information garnered from their websites and from the literature. We will also use information gathered informally and serendipitously via conversations on email lists, at conferences and other networking events. We have already gathered a list of roughly one dozen contacts of librarians who are interested in our current work and have indicated willingness to partner with us, simply from attending (and presenting at) conferences and seminars, or writing about our initiatives on relevant email lists.

When selecting partners, we will look at schools large and small, geographically diverse, and with varying student demographics. UT Arlington is a large urban university with the status of being a Hispanic-Serving Institution, and is ranked the fifth-most ethnically diverse campus in the U.S. by *U.S. News & World Report* (2017). UNR is a midsized land-grant institution. We will identify partners from other regions that substantively differ from our demographics in order to represent a diverse cross-section of academic library makerspaces nationally. We will also

seek to include partners from academic libraries with different makerspace sizes and capabilities. While a focus on demographic diversity and underserved student populations is outside the scope of this planning grant, we anticipate a potential fringe benefit of selecting our partners in this way will be that we gain a demographically diverse cross-section of students taking part in our pilot study. For the purposes of future research, we will solicit demographic profiles of students enrolled in pilot test courses from subject faculty.

Once we identify a pool of prospective partners using the above criteria, we will rank finalists based on appropriateness for participation in our pilot. Project investigators will then visit the top five finalists to observe their makerspaces and to interview librarians, subject faculty and staff involved with makerspace-curriculum integration. During the site visits we will inquire specifically about their 1) strategies for integrating their makerspaces into undergraduate course work, 2) expected goals and outcomes, 3) knowledge and expertise related to measuring student learning and 4) potential buy-in from subject faculty, especially those in non-STEAM disciplines. Once the site visits are concluded we will evaluate our findings using a rubric and secure three finalists as partners from this pool.

Making in the Humanities and Social Sciences

It is easy to see the connection between the STEAM disciplines and making. It is not as natural to imagine how humanities and social sciences students might benefit from the use of makerspaces. With the growing importance of digital humanities scholarship and cross-disciplinary objectives within the liberal arts, it is unsurprising that makerspaces are seeing use by non-STEAM disciplines. One such example is the University of Victoria's Maker Lab in the Humanities. This maker facility focuses on the intersections between making and the digital humanities. Although interdisciplinary work occurs in the space too, the major projects are dedicated to creating digital interfaces for historical documents and fabricating historical technologies. We have also seen use of the UTA FabLab by humanities and social sciences students. Two of the four courses that participated in testing of the beta maker-based competencies were from the humanities. We have also had social work students use the UTA FabLab to create assistive toys for use with children with disabilities and health sciences students make artifacts that can be used for health education.

Pilot Tests

Once selected, librarians at our four partner institutions (UNR plus three additional partners) will gain commitment from two subject faculty members each (8 total) to participate in pilot tests. UTA will have three faculty members participate, making a total of 11 subject faculty. When identifying prospective subject faculty for the pilot, we will look for support from a wide range of disciplines, including fields not usually considered relevant in maker-based education such as social sciences and humanities.

Librarians and faculty at each institution will work together to revise course assignments as needed to align maker competencies with their course learning outcomes and to develop assessment strategies that measure student learning. Key project personnel and an outside consultant from UTA's College of Education with expertise in curriculum design and assessment will be available to help with this process. Partners will receive funds to purchase consumable materials for use in their pilot assignments. Pilot faculty will receive stipends for work required to revise course assignments.

During this pilot phase, we will be testing the early-stage competencies as a whole to determine the feasibility of mapping the competencies to subject-based learning outcomes, and whether or not they can accurately be measured. We will find out if the language makes sense to those who would be adapting the competencies to their course assignments and refining as needed, and we will be soliciting recommendations for revising and expanding on the early-stage maker-based competencies from pilot participants. Actual assessment of student learning would

happen as part of an eventual IMLS Project Grant (if accepted) or through additional work that happens after the pilot has concluded. The goal of assessment of student work in this phase would be to determine measurability, with less emphasis on student learning itself. We will use this new knowledge to revise our early-stage work and draft best practices for broadening implementation.

Performance Evaluation

This planning grant is designed to answer the following questions: 1) How well do the beta competencies map to disciplinary learning outcomes? 2) How accurately do the beta competencies represent the transferable skills librarians and subject faculty expect to be acquired via making? and 3) What revisions would partners suggest to improve the beta competencies?

As we work to develop best practices, we will also evaluate the following: 4) What is the optimal collaborative relationship between librarians and subject faculty when developing maker-based curricula and assessments? 5) How measurable/assessable are the learning outcomes derived from the beta competencies? 6) What are the characteristics of maker-based assignments and/or learning activities that result in visible evidence of learning? 7) What assessment strategies and tools are most effective at measuring maker-based student learning? 8) What processes are most efficient for coordinating between subject faculty and makerspace staff (e.g. scheduling, acquiring materials, consultation with equipment experts, etc.)? and 9) What are the characteristics and competencies of librarians and subject faculty that are most successful at implementing maker-based curricula?

Partner librarians and subject faculty will apply a rubric, supplied by the grant's key personnel, to the beta competencies, their assignments and/or learning activities, and their assessment strategies. This rubric will be designed to elicit the efficacy of the beta competencies as well as the pedagogical and assessment strategies utilized during the pilots. The rubric will be supplemented by written narrative in which the participants provide feedback and suggestions for improving the beta competencies and developing best practices for competency integration and assessment. Once this evaluative content is received, each partner librarian and subject faculty will participate in an "exit interview" with the grant's key personnel. These semi-structured interviews will allow key personnel to ask questions raised by the evaluations and gather qualitative data relevant to the questions outlined above.

We will allow ample opportunities at all stages of the pilot to allow for input, consensus building, and buy-in from all program participants, including key personnel, partner librarians, subject faculty, and makerspace staff. We will be actively seeking feedback about our early-stage maker-based competencies from all stakeholders. We will seek feedback using regular communication with program participants, periodic mandatory reports from partner librarians, and through surveys from each librarian and faculty participant in accordance with IMLS Performance Measurement Goals. We will add additional questions to the evaluation survey that reflect our specific information needs.

Roles and Responsibilities

Academic Librarians & Staff at Partner Institutions

Librarians' and library staff from partner institutions' main responsibility will be identifying and collaborating with their subject faculty to develop projects or assignments with learning outcomes that can be mapped to our early-stage maker-based competencies. In addition, they will need to help schedule and coordinate course work in their libraries' makerspaces. They will submit periodic reports to the grant's key personnel about progress and problems that arise during their pilot implementations. Librarians from partner institutions will, at the end of the pilot, provide feedback via Performance Measures survey, narrative evaluation of pilot components, and a semi-structured interview that will help key personnel revise the maker competencies and develop best practices.

Subject Faculty

Subject faculty from partner institutions will collaborate with their librarians to develop learning outcomes and assignments that integrate the early-stage maker-based competencies into curricula. In addition, subject faculty must make certain that students complete an assignment(s) that makes it possible to assess the maker-based learning outcomes. Subject faculty will provide feedback about the assessability of the competencies selected for their assignments (actual student assessment data is not to be shared). Faculty from partner institutions will, at the end of the pilot, provide feedback via Performance Measures survey, narrative evaluation of pilot components, and a semi-structured interview that will help key personnel revise the maker competencies and develop best practices.

Key Personnel

The grant's key personnel will be responsible for identifying a pool of potential partners and selecting three additional partners. Potential partners will be rated according to a rubric developed by the key personnel. Once partners have been selected, key personnel will provide training to partner librarians on use and adaptation of the maker-based competencies. This group will solicit regular progress reports from partner institutions. Key personnel will develop rubrics and other program evaluation tools, and once participant feedback has been gathered we will be responsible for analyzing the efficacy of the maker competencies, revising the competencies, developing best practices for inclusion of makerspaces in course curricula, and communicating our findings. They will also write case studies, publish papers, present at conferences, and apply for the IMLS project grant.

With the exception of the Primary Investigator, key personnel will dedicate approximately 5-10% of their time to completion of this planning grant, depending on where we are in the project timeline. For each of the key personnel, this work is a personal or departmental priority and will therefore be balanced with other responsibilities accordingly. The Primary Investigator will commit up to 50% of their time to completion of the planning grant. Key personnel will include:

- Martin Wallace, Maker Literacies and Engineering Liaison Librarian, UTA Libraries, (PI). Mr. Wallace is the primary investigator for this planning grant and will be responsible for planning, implementing, and managing the pilot, communicating progress and results, and creating project deliverables.
- Gretchen Trkay, Department Head for Experiential Learning & Undergraduate Research, UTA. Ms. Trkay's primary role as a member of this grant's key personnel will be to consult with partner librarians and subject faculty to draft student learning outcomes (SLOs) that integrate maker-based competencies, create curricula and assignments based on these SLOs, and develop assessments tools that measure student learning.
- Katie Musick Peery, Director of FabLab, UTA Libraries. Mrs. Musick Peery's primary role will be to oversee the integration of the UTA FabLab into this campus's pilot courses and will serve as a consultant to the pilot partners on best practices and strategies for preparing their makerspaces for course integration.
- Tara Radniecki, Engineering Librarian, University of Nevada, Reno. Ms. Radniecki will serve as a partner librarian at UNR and serve on the key project team by assisting with analysis and synthesis of pilot evaluation data and with creating project deliverables.

Consultant

UTA has secured commitment from Dr. Kathryn Pole in the Department of Curriculum and Instruction, in UTA's College of Education, to serve as consultant on curriculum design and assessment methodology. Partner institutions may consult with experts at their own institutions, or turn to our consultant at UTA during this pilot phase.

Additional Personnel

Additional personnel that will play some part in this planning grant will be UTA Libraries' Director of Grants who will serve as our primary interface with IMLS, UTA's Office of Grants and Contract Services, and UTA's Grant

Accounting department. UTA Libraries' Budget Manager will disburse funds to participants and also work with Grant Accounting. We will also make use of makerspace staff at each partner library to assist students with course projects. We do not anticipate hiring additional staff.

Activities

Beginning July 2017, key personnel will analyze survey and landscape analysis data to identify academic libraries at which makerspaces are being utilized in undergraduate coursework. We will evaluate these institutions based on the criteria outlined in the Partner Selection section above, and rank them from most appropriate to least appropriate. Mr. Wallace (PI) will contact the top potential partners to communicate the goals of the project and to confirm their willingness to participate in the pilot program. Once five have agreed to participate in these preliminary interviews, key personnel will rotate visits (two for each site visit) to their locations to observe course activities and interview librarians, faculty, and staff. Librarians at each institution in this finalist pool will be responsible for coordinating with interested subject faculty so that the project personnel will be able to interview them about their specific courses during site visits. At the conclusion of site visits, key personnel will synthesize the group's findings and rank the finalists in order from most suitable to least suitable according to criteria outlined in the Partner Selection section above. Mr. Wallace will contact the top three finalists and issue memoranda of understanding (MOU) to each, outlining each party's rights and responsibilities in the pilot (See Digitalproduct.pdf for additional information about MOUs). If for any reason a potential partner in the top three cannot agree to terms, we will go to the next in the list until three have been formally accepted into the program. If we are still unable to secure three additional partners, we will go back to our ranked list and repeat this process. Once partners are finalized, partner academic library makerspaces will receive funds for the purchase of consumable materials that will be used in the pilots.

During fall 2017 semester, key personnel will work with the subject librarians, subject faculty, and staff at each partner institution to identify two courses each for inclusion in the spring 2018 test pilot. Ms. Trkay and consultant Dr. Pole will assist with aligning each course's or assignment's learning outcomes with maker-based competencies and developing assessment tools for each assignment. Mses. Musick Peery and Radniecki will offer strategies and best practices for successful makerspace–course integration. Instructors of these courses will receive a stipend for the work they perform to adapt their assignments to the pilot.

The pilot implementation will launch in spring 2018. Partner librarians at each institution will be responsible for facilitating the pilot, communicating with their faculty, and submitting periodic reports to Mr. Wallace throughout the semester. Upon the conclusion of the pilot tests, key personnel will use these reports, along with feedback from subject faculty regarding assessment of their students' work, and data from the Performance Measures survey, to evaluate the efficacy of the pilot and to synthesize best practices. Based on that assessment, the team will revise and share draft maker-based competencies and best practices through the UTA Libraries' website. At the end of the grant life cycle, key personnel will prepare an IMLS Project Grant proposal with pilot partners focused on wider implementation, additional testing, finalization, and broad dissemination of maker-based competencies and best practices and seek out opportunities to further present and publish results of the Planning Grant. See Scheduleofcompletion.pdf for timeline of these activities. See the National Impact section, below, for more detail about our plans for publishing, presenting and submitting an IMLS Project Grant proposal.

Risks

We have identified the following risks in pursing this pilot. First, there is the risk of not getting adequate follow-through from participating partner librarians and subject faculty. While subject faculty may be eager to participate in the program at first, it is possible that once their course begins they may find it difficult to track, document and report their progress since this program adds an additional level of reporting to already burdensome instruction

processes. Key personnel will mitigate this risk by keeping reporting requirements to a minimum and by maintaining regular communication with project participants. Another risk that we have identified is failing to get enough buy in from non-STEAM subject faculty. We are very interested in exploring maker-based transdisciplinary competencies in the broadest cross-section of subject disciplines. Course work completed in makerspaces is typically thought of to be STEAM-based education and not traditionally thought relevant to social sciences and humanities. While securing a decent sample of humanities and social sciences courses into this program may be difficult, it is very important to try. We have added criteria #4, inclusion of broad cross-section of subject disciplines, in our partner selection process to help avoid this risk.

3. National Impact

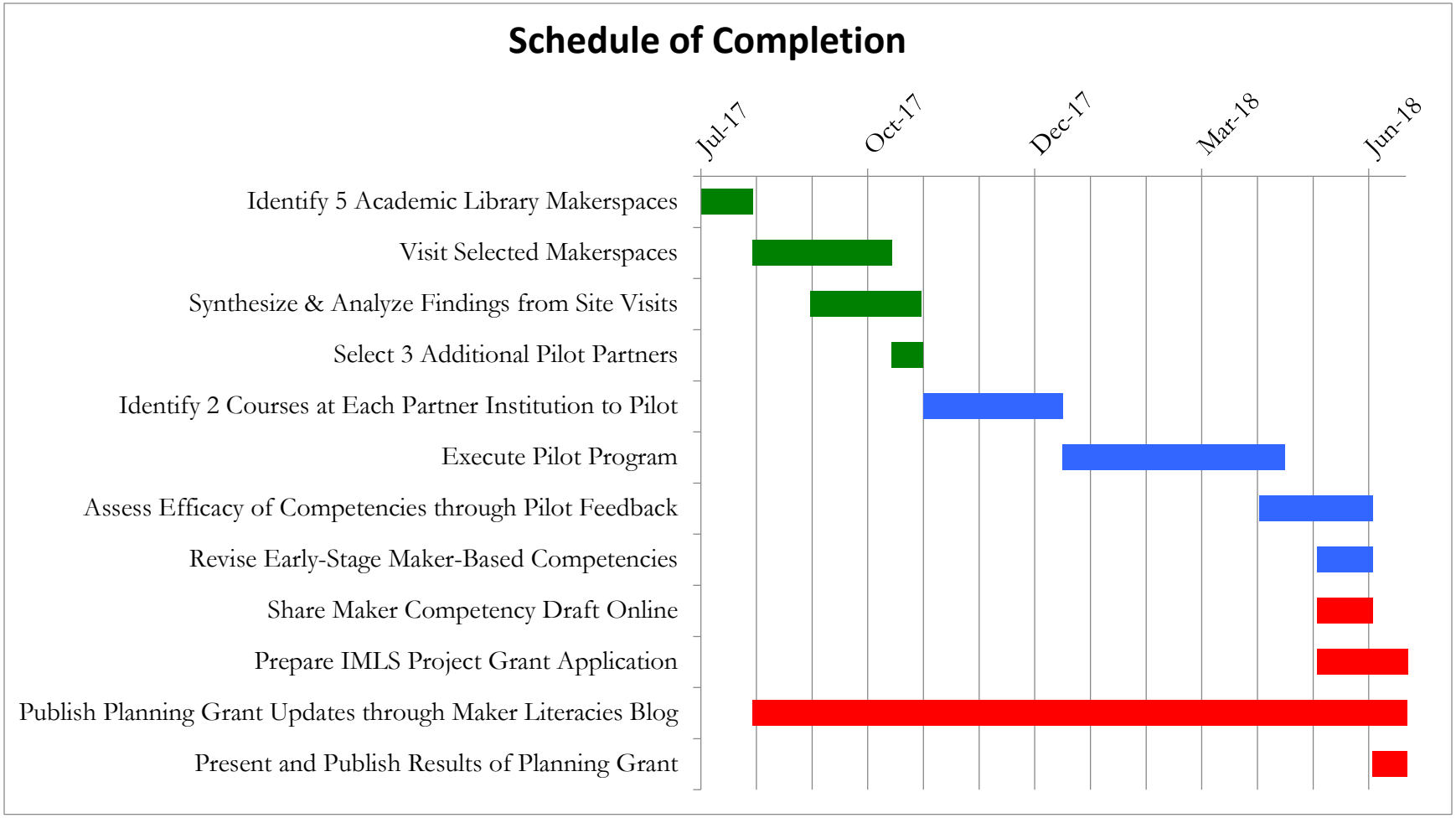
As indicated in our Statement of National Need, although there has been considerable growth in the inclusion of makerspaces in academic libraries, there is need for foundational work that helps librarians and faculty connect maker activities, transferable skills, and subject-based learning. This planning grant will fund a pilot that tests maker competencies that meet this need.

Throughout the implementation of the planning grant, the grant's key personnel will post regular blog entries on UTA Libraries' experiential learning blog Thinking Outside the Stacks that share our progress and encourage feedback. We will also share the findings of our pilot nationally through the UTA Libraries' website. We will provide individual case studies of each undergraduate course where early-stage maker competencies were tested. The case studies will include course descriptions, learning outcomes, and maker competencies that map to those outcomes. Additionally, we'll document assessment techniques for measuring student learning for each case study, specifically gauging transdisciplinary skills. Finally, we will include best practices for implementing the competencies more widely.

In addition to making key findings available via the UTA Libraries website, we will raise awareness that will lead to action in other ways. For example, we plan to share our findings by presenting a white paper at the International Symposium on Academic Makerspaces (ISAM). ISAM is a newly formed organization and has the potential to play a major role in how makerspaces are deployed in academic settings. We hope to start a national conversation about integrating makerspaces into the undergraduate curriculum and assessing the learning happening in them. At this stage, we will also be poised to begin presenting nationally and publishing in academic journals. In addition to ISAM, we have identified LITA Forum and ACRL conferences. Potential journals where we will publish include *Library Hi Tech*, *Journal of Academic Librarianship*, *College and Research Libraries*, and *portal: Libraries and the Academy*.

Successful completion of this Planning Grant will position us to submit an IMLS Project Grant application for implementing maker competencies into the broadest cross-section of undergraduate curriculum. For the widest dissemination of our findings, the Project Grant would allow us to establish national professional development opportunities and to develop a clearinghouse website of maker literacies information, such as lesson plans and assessment tools spanning all subject disciplines. In addition, we would like to expand on this work by developing a framework of threshold concepts to supplement the maker-based competencies. Such a framework would help librarians and subject faculty decide which competencies are most appropriate for scaffolding into various levels of undergraduate course work, from beginner to expert.

Maker Competencies and the Undergraduate Curriculum



DIGITAL PRODUCT FORM

Introduction
The Institute of Museum and Library Services (IMLS) is committed to expanding public access to federally funded digital products (i.e., digital content, resources, assets, software, and datasets). The products you create with IMLS funding require careful stewardship to protect and enhance their value, and they should be freely and readily available for use and re-use by libraries, archives, museums, and the public. However, applying these principles to the development and management of digital products can be challenging. Because technology is dynamic and because we do not want to inhibit innovation, we do not want to prescribe set standards and practices that could become quickly outdated. Instead, we ask that you answer questions that address specific aspects of creating and managing digital products. Like all components of your IMLS application, your answers will be used by IMLS staff and by expert peer reviewers to evaluate your application, and they will be important in determining whether your project will be funded.

Instructions
You must provide answers to the questions in Part I. In addition, you must also complete at least one of the subsequent sections. If you intend to create or collect digital content, resources, or assets, complete Part II. If you intend to develop software, complete Part III. If you intend to create a dataset, complete Part IV.

PART I: Intellectual Property Rights and Permissions

A.1 What will be the intellectual property status of the digital products (content, resources, assets, software, or datasets) you intend to create? Who will hold the copyright(s)? How will you explain property rights and permissions to potential users (for example, by assigning a non-restrictive license such as BSD, GNU, MIT, or Creative Commons to the product)? Explain and justify your licensing selections.

Our pilot project will involve partners from various institutions yet to be identified. Each of those partners may be held to their home institution's unique rules and guidelines regarding copyright and intellectual property. In general, where not in violation of those institution's rules and guidelines, all digital content objects that result from this pilot project will be protected by standard copyright and owned by the content creator(s). UT Arlington Libraries' policy is to encourage the use of Creative Commons licensing for copyrighted materials. Any content created by UT Arlington Libraries' staff will be licensed under CC by NC license and we will encourage our partners to do the same with any content that they contribute. Partners will sign a memorandum of understanding with our partners before any work is done so that they understand our position on Creative Commons licensing.

A.2 What ownership rights will your organization assert over the new digital products and what conditions will you impose on access and use? Explain and justify any terms of access and conditions of use and detail how you will notify potential users about relevant terms or conditions.

The primary location for digital products created in this pilot project will be the UTA Libraries' website. We will impose no restrictions on access and use other than those restrictions governed by standard copyright law. A significant portion of these materials will be licensed under Creative Commons, expanding the potential for their use and re-use. We will use memorandum of understanding to notify our partners before any content is published, and we will place a Creative Commons licensing notice on the web pages where content is accessed by users.

A.3 If you will create any products that may involve privacy concerns, require obtaining permissions or rights, or raise any cultural sensitivities, describe the issues and how you plan to address them.

Our pilot will require that subject faculty assess student learning by performance review (grades, project outputs, etc.). Only those subject faculty will see their students' grades and personally identifying information, and the project team will only see aggregate/summarized

information provided to us by the subject faculty. We will only publish aggregated results. Any student work that we publish as samples in our case studies will be anonymized. The primary investigator and all co-investigators at UT Arlington have completed human subjects research training. There is no human subject research involved and therefore is deemed exempt by UTA's Institutional Review Board.

In addition, this pilot project will involve participation from librarians, faculty and staff at several partner institutions. Individuals from partner institutions will be required to agree to and sign a memorandum of understanding that will stipulate copyright ownership, rights for re-use and sharing, and rights for publishing/presenting work derived from this pilot project. All collaborators will be free to publish/present work derived from this pilot as long as they properly cite and give credit to others who were involved. We will require notice of all publications/presentations that derive from our pilot and the work to be as openly available as possible, educating authors about retaining their rights. We will publish materials on our website when possible. If publisher agreements do not allow this, we will publish the abstract, summary, or pre-print. For those publications that are embargoed, we will make the work available on our website once we are free to do so.

Part II: Projects Creating or Collecting Digital Content, Resources, or Assets

A. Creating or Collecting New Digital Content, Resources, or Assets

A.1 Describe the digital content, resources, or assets you will create or collect, the quantities of each type, and format you will use.

We will publish all outputs of this pilot project on the UTA Libraries' website. Content will include revised maker-based competencies, best practices for incorporating makerspaces and maker-based competencies into the curriculum, and a series of case studies of each course that participated in the pilot (up to 11).

For each course, we will publish the course name and description, the assignment or project prompt, the competencies that were mapped to the course/assignment learning outcomes, and assessment tools/techniques used for assessing student learning. Case studies may also include photos of objects made by students in the makerspaces, .stl (3D printing) files, examples of student work, etc.

We will also post the full text (or a citation to the full text, if the author has given up their copyright to the publisher) of all publications/presentations that derive from our pilot on this website. If available, we will post video (or links to video) of any presentations that derived from this work.

A.2 List the equipment, software, and supplies that you will use to create the content, resources, or assets, or the name of the service provider that will perform the work.

The UTA Libraries' website uses the Drupal content management system which allows for publishing content of all types. We will consult with our digital archivist to determine best practices for publishing audio/visual materials (if applicable). All textual content will be created by the pilot project team.

A.3 List all the digital file formats (e.g., XML, TIFF, MPEG) you plan to use, along with the relevant information about the appropriate quality standards (e.g., resolution, sampling rate, or pixel dimensions).

The majority of our content will be text, added to the website using Drupal interface. Images will be .png or .tiff format, depending on the quality guidelines required. Sample materials from our pilot courses will be posted as PDF with CC license, following best practices for authors' right management.

B. Workflow and Asset Maintenance/Preservation

B.1 Describe your quality control plan (i.e., how you will monitor and evaluate your workflow and products).

We will adhere to Section 508 Federal guidelines for accessibility/usability for all web pages and digital objects created. In addition, we will consult with the UTA Libraries' scholarly communications division for best practices in creating digital objects, if applicable.

B.2 Describe your plan for preserving and maintaining digital assets during and after the award period of performance. Your plan may address storage systems, shared repositories, technical documentation, migration planning, and commitment of organizational funding for these purposes. Please note: You may charge the federal award before closeout for the costs of publication or sharing of research results if the costs are not incurred during the period of performance of the federal award (see 2 C.F.R. § 200.461).

We will consult with the UTA Libraries' scholarly communications division for best practices in long term preservation of digital objects, if applicable. When relevant, we will also utilize the services and expertise of the university's office of technology.

C. Metadata

C.1 Describe how you will produce any and all technical, descriptive, administrative, or preservation metadata. Specify which standards you will use for the metadata structure (e.g., MARC, Dublin Core, Encoded Archival Description, PBCore, PREMIS) and metadata content (e.g., thesauri).

UTA Libraries uses Dublin Core as its metadata structure.

C.2 Explain your strategy for preserving and maintaining metadata created or collected during and after the award period of performance.

Digital content associated with this planning project, including descriptive metadata, will be hosted in UTA's institutional repository.

C.3 Explain what metadata sharing and/or other strategies you will use to facilitate widespread discovery and use of the digital content, resources, or assets created during your project (e.g., an API [Application Programming Interface], contributions to a digital platform, or other ways you might enable batch queries and retrieval of metadata).

Digital content associated with this planning project, including descriptive metadata, will be hosted in UTA's institutional repository. This will allow discoverability on multiple platforms, including the open web and UTA's catalog.

D. Access and Use

D.1 Describe how you will make the digital content, resources, or assets available to the public. Include details such as the delivery strategy (e.g., openly available online, available to specified audiences) and underlying hardware/software platforms and infrastructure (e.g., specific digital repository software or leased services, accessibility via standard web

browsers, requirements for special software tools in order to use the content).

All published content will be posted online and available/accessible to anyone, with respect to standard copyright law as explained above. No special software or equipment will be necessary to access our content.

D.2 Provide the name(s) and URL(s) (Uniform Resource Locator) for any examples of previous digital content, resources, or assets your organization has created.

UTA Libraries' Digital Collections:
http://library.uta.edu/collections/digital

Part III. Projects Developing Software

A. General Information

A.1 Describe the software you intend to create, including a summary of the major functions it will perform and the intended primary audience(s) it will serve.

A.2 List other existing software that wholly or partially performs the same functions, and explain how the software you intend to create is different, and justify why those differences are significant and necessary.

B. Technical Information

B.1 List the programming languages, platforms, software, or other applications you will use to create your software and explain why you chose them.

B.2 Describe how the software you intend to create will extend or interoperate with relevant existing software.

B.3 Describe any underlying additional software or system dependencies necessary to run the software you intend to create.

B.4 Describe the processes you will use for development, documentation, and for maintaining and updating documentation for users of the software.

B.5 Provide the name(s) and URL(s) for examples of any previous software your organization has created.

C. Access and Use

C.1 We expect applicants seeking federal funds for software to develop and release these products under open-source licenses to maximize access and promote reuse. What ownership rights will your organization assert over the software you intend to create, and what conditions will you impose on its access and use? Identify and explain the license under which

you will release source code for the software you develop (e.g., BSD, GNU, or MIT software licenses). Explain and justify any prohibitive terms or conditions of use or access and detail how you will notify potential users about relevant terms and conditions.

C.2 Describe how you will make the software and source code available to the public and/or its intended users.

C.3 Identify where you will deposit the source code for the software you intend to develop:

Name of publicly accessible source code repository:

URL:

Part IV: Projects Creating Datasets

A.1 Identify the type of data you plan to collect or generate, and the purpose or intended use to which you expect it to be put. Describe the method(s) you will use and the approximate dates or intervals at which you will collect or generate it.

A.2 Does the proposed data collection or research activity require approval by any internal review panel or institutional review board (IRB)? If so, has the proposed research activity been approved? If not, what is your plan for securing approval?

A.3 Will you collect any personally identifiable information (PII), confidential information (e.g., trade secrets), or proprietary information? If so, detail the specific steps you will take to protect such information while you prepare the data files for public release (e.g., data anonymization, data suppression PII, or synthetic data).

A.4 If you will collect additional documentation, such as consent agreements, along with the data, describe plans for preserving the documentation and ensuring that its relationship to the collected data is maintained.

A.5 What methods will you use to collect or generate the data? Provide details about any technical requirements or dependencies that would be necessary for understanding, retrieving, displaying, or processing the dataset(s).

A.6 What documentation (e.g., data documentation, codebooks) will you capture or create along with the dataset(s)? Where will the documentation be stored and in what format(s)? How will you permanently associate and manage the documentation with the dataset(s) it describes?

A.7 What is your plan for archiving, managing, and disseminating data after the completion of the award-funded project?

A.8 Identify where you will deposit the dataset(s):

Name of repository:

URL:

A.9 When and how frequently will you review this data management plan? How will the implementation be monitored?