INSTITUTE of Museum and Library SERVICES

FINAL PERFORMANCE REPORT

Please consult attached instructions when filling out this form.

1. Federal agency and organization element to which report is submitted: **Institute of Museum and Library Services**	2. Federal award or other identifying number assigned by federal agency: LG-97-17-0010-17	Page 1	of 24 Pages
		3a. DUNS number: 0642346100000	
		3b. EIN/TIN: 75-6000121	
4. Recipient organization (name and complete address, including ZIP+4/postal code): The University of Texas at Arlington, 701 S. Nedderman Drive, Box 19145, Arlington, TX 76019-0145		5. Recipient identifying or account number:	
6a. Award period of performance start date (mo/day/yr): 07/01/17	6b. Award period of performance end date (mo/day/yr): 06/30/19	7. Reporting period end date (mo/day/yr): 09/28/19	
8. Project URLs, if any: https://library.uta.edu/makerliteracies		9. Report frequency: **annual** ~~semi-annual~~ ~~quarterly~~ ~~other~~ If other, describe:	
10. Other attachments? No Contact the IMLS program office to receive instructions for transmitting additional attachments.			
11a. Name and title of Project Director: Martin Wallace, Maker Literacies Librarian		11b. Telephone (area code, number, extension): 817-272-3924	
		11c. Email address: martin.wallace@uta.edu	
12. Certification: By submitting this report I certify to the best of my knowledge and belief that this information is correct and complete for performance of activities for the purposes set forth in the award documents.			
13a. Signature of Authorized Certifying Official:		13b. Date report submitted (mo/day/yr):	
13c. Name and title of Authorized Certifying Official: Duane Dimos, Vice President for Research		13d. Telephone (area code, number, extension): 817-272-2105	
		13e. Email address: ogcs@uta.edu	
		14. Agency use only	

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The purpose of the final performance report is to provide a record of grant-funded project accomplishments at the conclusion of the grant. IMLS uses these narratives to report to Congress and the Office of Management and Budget about the agency's progress on addressing its strategic goals. If you have questions concerning the final performance reporting requirements, you may address them to the Program Officer who is assigned to your grant and whose name and contact information appear in your Official Award Notification. IMLS may share final performance reports with grantees, potential grantees, and the general public to further the mission of the agency and the development of museum and library services. Reports may be disseminated in a variety of ways and formats, including online.

15. Recipient Organization:

University of Texas at Arlington

16. Project Title:

Maker Competencies and the Undergraduate Curriculum

17. Project Summary:

The list of maker-based competencies compiled in 2016 by UTA Libraries' Maker Literacies Task Force provides a framework for assessing the learning that results when making and design thinking are integrated into curricula. The proof-of-concept pilot funded by this planning grant integrates these competencies into the curricula of a diverse selection of 17 undergraduate courses spread across five institutions.

The goal of the spring 2018 implementation was to answer three questions: 1) How well do our competencies map to disciplinary learning outcomes? 2) How accurately do they 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? From the conclusions of our study, we provide discussion of these questions and more in the Lessons Learned section of this report.

Before we could begin, we needed to select three additional partners with which to pilot our program. Over fall 2017 we developed a scoring rubric for ranking potential partners, and then visited the top five locations to further narrow them. We were looking for a good cross-section of academic library makerspaces, representing different campus and makerspace sizes, equipment availability, and student demographics. We achieved our goal when after rigorous review, Boise State, UMass Amherst and UNC Chapel Hill accepted our invitations to join UTA and UN Reno—our preexisting partner—to conduct this pilot.

Our primary audience—academic librarians and subject faculty—gained an understanding of how making and design thinking apply to their subject disciplines, and how to integrate makerspaces into their curricula. They collaborated in new and exciting ways, and learned more about curriculum design and measuring student learning. We measured our overall success by use of an exhaustive exit survey required by all librarian and subject faculty participants.

18. Activities

Activities Proposed in Your Application	Activities Completed during the Award Period of Performance	Explanation of Any Variance
Identify and select program partners	• Developed a partner selection rubric for scoring and sorting potential institutions (see Appendix 1). • Visited top five sites. • Synthesized and analyzed findings from site visits with partner selection rubric.	The application states: "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." As it turned out, Mr. Wallace was the wrong person for this. Each partner site had to go through a different contract negotiation process

	• Invited three of five finalists for partnerships. • A detailed description of our partner selection process is included in: Wallace, Martin K., Gretchen Trkay, Katie Musick Peery, Morgan Chivers, and Tara Radniecki. "Maker Competencies and the Undergraduate Curriculum." Paper presented at the International Symposium on Academic Makerspaces, Stanford, CA, August 3-5, 2018. https://rc.library.uta.edu/uta-ir/handle/10106/27518	between their Office of Research and our Office of Research. It took much longer than we planned. Some of them were not finalized until after the work was well underway. Lesson learned.
Identify and select two courses at each partner site, four at UTA; look for support from a wide range of disciplines, including fields not usually considered relevant in maker-based education	• Identified and selected two courses each at BSU, UMA and UNR; four courses at UNC; and seven at UTA. • Includes courses in: Architecture, Art, Biology, Civil Engineering, Computer Science, Education, English, Geology, History, Industrial Engineering, Mathematics, Philosophy, and Public Administration.	Some faculty at UNC and UTA agreed to participate without stipends, resulting in more faculty participation than originally planned.
Execute pilot program	• Aligned makerspace competencies with course learning outcomes. • Created new or adapted existing assignments that incorporate making into the curriculum and lead to the desired course learning outcomes. • Developed and implemented standardized pre- and post-self-assessment surveys for measuring competencies attainment; pre- and post- survey question banks are available at: https://doi.org/10.18738/T8/ZCZF6X. • In total, over 350 students, enrolled in 17 different courses spread across five campuses, representing 13 distinct disciplines, all completed a project in their academic library makerspaces during the spring 2018 semester as part of the IMLS-funded pilot program. 169 of these students completed pre- and post-self-assessment surveys, from which we've gathered data for further study of the learning that takes place in makerspaces. • A detailed description of our survey method is included in: Wallace, Martin K., Gretchen Trkay, Katie Musick Peery, Morgan Chivers, and Tara Radniecki. "Maker Competencies and the Undergraduate Curriculum." Paper presented at the International Symposium on Academic Makerspaces, Stanford, CA, August 3-5, 2018. https://rc.library.uta.edu/uta-ir/handle/10106/27518	• The grant's primary personnel and a consultant were available to assist with aligning each assignment's learning outcomes with maker-based competencies, developing assessment tools for each assignment, and offering strategies and best practices for successful makerspace–course integration; one participating faculty at a partner site and four at UTA requested consultations. Several partner sites had their own curriculum experts with whom their faculty members could chose to work with. Some faculty members did not seek any consultation. • The pre- and post-self-assessment survey was not a factor in the grant proposal; we developed this system for our own use between the times when the grant proposal was submitted and rewarded, and decided to make it an option for our partner sites during the grant award period. All of them elected to have their students participate. Due to IRB rules, students were given the option to opt-out from participation in the study.

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.	• Created and administered an exhaustive pilot feedback survey for all participating librarians, faculty members and selected makerspace staff. See Appendix 4.	• We decided that one well-designed survey could capture nearly all the information that we needed, and it would be easier for participating faculty than using the rubric method and writing a narrative. The survey offers plenty opportunity for open ended narrative responses. • We did not abandon the exit interview idea, but none were needed. Survey responses provided ample information. • Rather than administer two surveys, the pilot feedback survey also included Likert scale questions for each of the IMLS mandated Performance Measures Statements. Answers to these questions are summarized in the "Results" section, below.
Synthesize and findings from pilot feedback surveys of participating librarians, faculty members and selected makerspace staff.	The five-member grant team, with assistance of program consultant from UTA's Department of Curriculum and Instruction in the College of Education, reviewed and evaluated each survey response in order to answer the three primary research questions plus six ancillary research questions as outlined in the "Performance Evaluation" section of our planning grant proposal. Our findings are described in the "Lessons Learned" section of this report, below.	N/A
Revise the list of early-stage maker competencies based on participant feedback survey responses.	We successfully revised the list of maker based competencies. See Appendix 3 for the list, or view our official publication "List of Maker Competencies, Including Preamble and Acknowledgments" at http://hdl.handle.net/10106/27634.	This version replaces/supersedes the version supplied in Appendix 3 of our September 2018 Interim Report. After that version was reviewed by program participants, it became clear that the grant team had not reached consensus on all aspects of that version, so we conducted another round of revisions and gained consensus from stakeholders. This version was officially announced and published in December 2018.
Develop best practices for integration of makerspaces into undergraduate course curricula.	While we have outlined and described some best practices in the "Discussion" section, below, this work is ongoing.	The outcomes from this pilot program and its associated IMLS planning grant could only get us so far in developing best-practices. We have additional work to do in this regard; specifically as related to 1) professional development around librarian/faculty/makerspace staff collaborative curriculum design and 2) assessment of student learning in makerspaces.

Create a repository of makerspace curricula for undergraduate courses; publish curricula from the Maker Literacies pilot program.	We successfully created a repository, collected curricula from the pilot program and published it to the repository under Creative Commons licensing. The repository currently contains curricula from 29 unique courses spanning 13 subject disciplines. Some of this curricula was from the UTA-only pilot (pre-IMLS planning grant) and some is from fall 2018, after the conclusion of the IMLS planning grant work. The repository will be continually updated with new curricula. See https://library.uta.edu/makerliteracies/lesson-plans.	N/A
Communicate our findings through written case studies, published papers, and conference presentations.	Throughout the lifecycle of the IMLS planning grant we have communicated our progress and findings on the Maker Literacies website blog. We have also published selected case studies on the blog. See https://library.uta.edu/makerliteracies/blog. Additionally we have published a few papers and presented at a few conferences. See Appendix 5: Presentations and Publications Resulting from this Work.	N/A
Apply for an IMLS National Leadership for Libraries Project Grant to further expand and improve the Maker Literacies program.	We have successfully applied for an IMLS National Leadership for Libraries Project Grant for the 2019 funding cycle.	N/A

19. Changes

Type of Change	Description	Date of Approval (if applicable)
Key Personnel	Added Morgan Chivers, UTA's FabLab Librarian, to the project team.	Friday, July 14, 2017
Partners	This change later reversed itself, so we don't know if it should be included. We had enough funds remaining from travel (site visits) to invite a 4th partner. The 4th partner accepted our invitation, but shortly thereafter they withdrew from the project.	Approval to invite 4th partner: November 13, 2017 Withdrawal from program: February 12, 2018
Travel	Used remaining travel funds, left over from site visits, to send three key personnel to the International Symposium on Academic Makerspaces, Stanford, CA, August 3-5, 2018.	February 26, 2018
Extension	Because we needed to be able to spend money from grant funds to reimburse our three travelers to the 2018 ISAM Conference in August, we requested a 90-day extension (beyond the original June 30, 2018 deadline). We received a 1-year extension.	March 12, 2018

20. Results

a. Agency-Level Goals and Performance Goals

Learning

- ☐ Train and develop museum and library professionals
- ☐ Support communities of practice
- ☐ Develop and provide inclusive and accessible learning opportunities

Community

- ✓ Strengthen museums and libraries as essential partners in addressing the needs of their communities

Content and Collections

- ☐ Broaden access and expand use of the Nation's content and collections
- ☐ Improve management of the Nation's content and collections
- ☐ Improve preservation, conservation, and care of the Nation's content and collections

For **Learning** and **Community** projects

Performance Measure Statement	Survey Respondent	No. of Participants	No. Total Responses	No. Responses Per Answer Option				No. Non Responses
				Strongly Disagree	Disagree	Agree	Strongly Agree	
The library is better prepared to collaborate with faculty to incorporate maker-based competencies into curricula.	Librarians & Selected Makerspace Staff	11	8				8	3
My library is better able to engage faculty with maker-based learning and competencies.	Librarians & Selected Makerspace Staff	11	8			1	7	3
My library is better prepared to develop and maintain on-going relationships with faculty related to maker-based learning.	Librarians & Selected Makerspace Staff	11	8				8	3
My library is better prepared to share knowledge and other resources as an active contributor to problem solving related to maker-based learning.	Librarians & Selected Makerspace Staff	11	8			1	7	3

The library offers programs, services, or resources that address community needs related to maker-based learning.	Subject Faculty members	17	15			5	10	2
The library is an active contributor to problem solving related to maker-based learning.	Subject Faculty members	17	15			4	11	2

21. Lessons Learned

This planning grant was 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 worked to develop best practices, we also evaluated the following questions: 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?

The following sub-sections 1-9 elaborate on our findings for each of these questions. The Discussion sub-section below them includes our recommendations for best-practices in makerspace-course integration.

1) How well do our competencies map to disciplinary learning outcomes?

All participating faculty and librarians, plus selected makerspace staff, were invited to take a post-project feedback survey. 18 out of 21 (86%) of respondents to the question “How easily did the beta maker competencies map to your (or your faculty member's) course(s) or assignment learning outcomes?” felt that the beta maker competencies were easy or very easy to map to their course’s or assignment’s learning outcomes. In most cases, the competencies matched up well to existing course learning outcomes and appeared conducive to overall existing goals the faculty members already had for their classes. It was often stated that it was more difficult to narrow down to an appropriate number of competencies when so many seemed relevant. Some faculty members also mentioned that the beta maker competencies encouraged them to think more deeply about their existing learning outcomes and helped in the revision of them and development of new ones. Those who felt the beta maker competencies were difficult to map to their course’s learning outcomes cited the language of the competencies as at fault. Faculty from outside the traditional STEM disciplines sometimes felt the competencies spoke to science and engineering only, employing too much jargon and didn’t match up well to existing learning outcomes as written.

2) How accurately do they represent the transferable skills librarians and subject faculty expect to be acquired via making?

Participants were asked how well the beta maker competencies represented the transferable skills they wanted their students to learn. 16 out of 21 (76%) of respondents to the question "How well did the beta maker competencies represent the transferable skills you want students to learn?" stated that they represented the desired transferable skills moderately well or very well. They felt the competencies were broadly applicable regardless of discipline. They supported transferable skills of public historians including content development, technology selection, project management, and audience. They also help future educators acquire skills that will contribute to better curriculum design and spoke to many of the skills technical writers need in determining how to best accomplish their task in the face of budgetary constraints, media involved and available, and applications and equipment they have to work with. Those who stated they aligned only slightly well or not well again stated that some of the competencies, or least the language used to write them, did not speak well to their particular non-STEM disciplines. The beta maker competencies also seemed jargon heavy and unclear to some participants.

3) What revisions would partners suggest to improve the beta competencies?

Participants were asked for their suggestions for improving the list of maker competencies. In addition to Likert scale questions asking participants to rank each of the competencies for their ease of mapping to their curriculum, we also included open-ended questions soliciting feedback for all eleven of the beta maker competencies. We received a great deal of very helpful feedback, resulting in our revised draft as shown in Appendix 3. Rather than explain the many changes made in detail, we recommend comparing the two versions. The original competencies are listed in Appendix 2.

4) What is the optimal collaborative relationship between librarians and subject faculty when developing maker-based curricula and assessments?

As part of this project, the intent was for librarians and makerspace staff to function as maker curriculum development experts. Through conversations with various partner librarians and makerspace staff, it became apparent that the majority of faculty chosen to participate in the project were existing users of the library, either of the makerspace itself or of more traditional resources and services, and had existing working relationships with librarian and staff. Pre-existing relationships such as these appeared to have the highest success.

Once the partner librarians selected faculty participants, they worked together to choose a limited number of beta maker competencies which either matched or complimented existing course learning outcomes or described a new knowledge set the faculty member wished for students to acquire. At this point, the librarians and faculty could bring in the grant team's curriculum experts to help develop course assignments and projects that would both teach the selected beta maker competencies and could be reliably assessed. However, often the development of assignments was done without the curriculum expert's assistance and instead took place between the faculty member and librarian and/or makerspace staff. While at the time this did not seem to cause difficulty, post-project discussions and survey feedback expressed a need for professional development on not only what the beta maker competencies are but also how to incorporate them into curriculum. During the assignment creation phase, the importance of having someone involved in the makerspace participate was clear in helping to create projects that were at an appropriate skill level for the students and utilized the most appropriate equipment and materials to meet the assignment objectives, and could supported by the makerspace for a large group.

5) How measurable/assessable are the learning outcomes derived from the beta competencies?

While assessment was not the primary focus of this grant project, participants were asked how easy it was to measure student learning mapped to the beta maker competencies. The assessability of the beta maker competencies directly informed the revision work done by the grant team on the competencies themselves, and will inform future work on assessment procedures and training for faculty and librarian participants. Ranking options were very easy, easy, neutral, difficult or very difficult. All competencies received a majority of positive rankings (easy or very easy) but all competencies also received a few neutral or negative rankings. While all competencies were queried separately, there were overarching themes that came through. For those responses that felt the beta maker competencies were easy or very easy to assess, most often, the competency was written directly into the assignment, explicitly addressed in a grading rubric, or was visible to the instructor via a self-reflection piece of the project. Other instructors noted they were able to informally observe the acquisition of the learning outcome by their students through class discussions, weekly progress reports, and presentations.

Those who felt the competencies were difficult to assess seemed to have neglected incorporating the competencies into a grading rubric when creating the assignments. In some cases, instructors stated that student journals and other self-reflection pieces could have been helpful in gathering the rich data points needed to assess some competencies, such as applying design praxis. Others pointed out that some competencies are acquired outside the classroom, making it difficult to observe how well the students learned it, such as the competency regarding employing safety precautions. Many of the faculty members also created the assignment as a group project, which caused some difficulty in determining how well the competencies were acquired by each team member. While there were certainly challenges in assessing competencies in certain courses, it appears that many of these problems could be addressed by developing and implementing assessment best practices tied directly to individual competencies. By creating rubrics and assignments tailored to the competencies, faculty and librarians can be certain of which skills are being acquired and where curriculum changes may need to be made.

6) What are the characteristics of maker-based assignments and/or learning activities that result in visible evidence of learning?

We found that group and team-based projects garnered the most visible evidence of success. This may be the result of teams being able to break projects into smaller parts and divided amongst team members. Students may also feel more motivated and held to account when working in groups.

7) What assessment strategies and tools are most effective at measuring maker-based student learning?

Formative assessment by way of student self-reflection was most effective at measuring maker-based student learning. Assignments that required students to reflect on their learning, specifically with regard to the maker competencies being measured, were easiest to assess. Some courses required students to give oral presentations while others asked students to submit written reflections in journals. Reflective components are more useful for assessing the often unseen processes of making than exams.

8) What processes are most efficient for coordinating between subject faculty and makerspace staff (e.g. scheduling, acquiring materials, consultation with equipment experts, etc.)?

In order to assess needs, establish realistic goals, map competencies, and design curriculum, consultation between librarian, makerspace staff and faculty members should happen well in advance of the beginning of the course. After that, librarians and makerspace staff need to work with faculty on an on-going basis. Librarians and staff should provide training for students on equipment and software, both at point of need outside of class and during more formal in-class

instruction sessions. Ideally, librarians and makerspace staff should attend class sessions several times to give instruction and assistance and in others.

9) What are the characteristics and competencies of librarians and subject faculty that are most successful at implementing maker-based curricula?

Although consultation opportunities with grant personnel who had curriculum development expertise were made available to all, librarians and faculty did not avail themselves of this service, preferring to work solely within their own institutions. In most cases, in their feedback surveys, the librarians indicated that they did not feel confident in their ability to act as curriculum development experts. Additionally, faculty indicated that they saw a need for more contextualized instructional content with a very narrow scope determined by the project and learning outcomes.

Discussion

This section will describe additional findings from the pilot program not included in the outline above, and will lay out some best practices for integrating makerspaces into the undergraduate curriculum.

Curriculum Development

Review of the assignments and curricula used in pilot courses revealed incongruence between the maker competencies the faculty members initially selected and what was actually represented in the curricula. Therefore, as a best-practice, early in the curriculum design process librarians and makerspace staff should make sure that their faculty members fully understand the competencies mapping process so that they are selecting, and later assessing, the most relevant competencies for their course. During the competencies selection process, faculty members should also be thinking about how they might assess their chosen competencies.

Stephen Crowley (BSU) states thusly: “It seemed as if every [beta maker competency] was linked to my activity to some degree or in some way. *So the challenge was to work out what were the most central parts of the activity to me (as instructor) and then focus on a small number of bmc's that most closely fitted my own goals for the activity…* I want to say it was 'too easy' to map the bmc's to my activity and more difficult but really valuable to think about how to map the bmc's to the activity meaningfully - that is, in a way that got me to think more clearly and deeply about what I wanted out of the activity.”

At least one faculty member, Amanda Alexander (UTA), created curriculum from scratch, with projects and assessment strategies derived directly from the maker competencies. We felt that this strategy was highly successful, especially due to her inclusion of periodic, formative assessment by way of written student reflection that focused specifically on the maker competencies selected for the course.

Paula Noble (UNR) and Leslie Madsen-Brooks (BSU) suggest starting with a fun, low-risk, yet relevant maker activity early in the semester to acclimate students to making before the actual makerspace assignment is introduced. One participating faculty member, Katy Beebe (UTA) did a mini-maker assignment with her Medieval Science & Technology students near the beginning of the semester, which proved invaluable in their larger class projects.

Whether or not students receive a mini-maker experience to get them acclimated, all projects should be preceded by hands-on training session provided by makerspace staff or other expert. It is very important that these be hands-on, introductory-level, and laser-focused to the course project. The following three quotations received from the feedback surveys exemplify problems encountered by not providing adequate hands-on training:

> "The initial training gave LOTS of information in a lecture format, which did little to help students be able to utilize the tools. Providing better hands on instruction and simple beginner guides would have saved students time and frustration and, ultimately, allowed for better products in the end."
>
> "Online videos were either too highly technical (not introductory enough) or too general, lending no help to students running into specific issues."
>
> "Those who conduct trainings in the Maker Spaces need pedagogical tools to be able to teach effectively. As a teacher educator, I was often frustrated--as were my students--with the ineffective trainings. Many were passive trainings--which seems particularly problematic given the nature of making."

Establishing detailed project design specifications and constraints helps students achieve the degree of precision required for success. When developing curricula, the team should seek the optimal balance between completely open-ended projects where students may feel overwhelmed and lost, and project with so many constraints that students are unable to find a creative/expressive niche. The sweet spot would be assignments that both guide students through the project by use of reasonable constraints, while remaining flexible enough to allow exploration, creativity, and expression.

Paula Noble (UNR) states the problem thusly: "Our group of students had next to no exposure to makerspace technologies. It was so new, they muddled around quite a bit at the beginning before becoming engaged. This is an area where we could have provided more structure to the project and built in assessments to get them through it." Stephen Crowley (BSU) says that if his students were not motivated, engaged and thinking about the process, they might have "stalled out in the face of all the uncertainty associated with the project." Alex Schreyer (UMass) mentions explicitly limiting the (software) tools and 3D printing equipment that his students were allowed to use in order to streamline facilitation of the course and limit uncertainty.

Instructors who placed students in pairs, groups or teams reported that students were better able to navigate frustrations and problem solving, and that having fewer total projects made it easier to grade and assess. Several participating faculty members who did not place their students in teams reported in their feedback that their students might have been more successful if they had been.

If the project/assignment is framed as a real-world solution (or even better, if it is a service learning project) then students will have completed a project/solved a problem that they can include in a resume and be able to take those skills with them into the workplace. To further reinforce this "real world application" idea, students can be required to present at a conference/expo or publish their work in a scholarly, trade, or special interest publication, or a public performance. Note that Charlie Schweik's (UMass) Public Policy & Administration course is framed entirely around students solving real-world problems. This should be a consideration for similar courses.

We discovered a reoccurring theme surrounding "budgeting of time", particularly related to learning curves and equipment availability. Not only is equipment often in use by others, but also there is downtime for repairs. Some institutions require scheduling in advance. Curriculum should take these into account and be structured in a way that "forces" students to take initiative and stay on top of their projects by regularly checking in about equipment availability. A way to reinforce this would be to require regular (weekly or bi-weekly) progress reports throughout the project duration where students explain how they are managing time on their projects, and what obstacles they encounter with time management.

Assessment of Student Learning

A majority of faculty articulated that they were confident their students demonstrated increased competencies, yet they didn't feel they were able to capture evidence of student learning as it happened.

Faculty should develop mixed qualitative & quantitative assessment that includes formative and summative components. While hard data is not typically collected by faculty, the pre-/post-self-assessment surveys administered by the program lend additional credibility & support to the qualitative and anecdotal information gathered by faculty. Participating faculty should make every reasonable and allowable effort to encourage student participation in these surveys. Some IRBs will not allow faculty to compel participation in the surveys; therefore individual IRBs should be consulted at each participating institution.

Faculty should incorporate routine formative assessment activities such as progress reports/presentations or journal entries in order to insure students are staying on top of their projects. Ideally these will include a reflective element for students to reflect on their progress. Even journaling assignments, usually very open-ended, should come along with a general list of examples of things they might discuss/reflect upon so that students' journal entries can be readily mapped to the course learning outcomes and/or maker competencies.

Jennifer Coble (UNC) conducted weekly formative assessment. While this allowed her to keep close track of student progress and make sure they were progressing week to week, it was a difficult grading load for her to review updates and provide feedback each week. As a best practices recommendation, perhaps two or three formative assessments over the course of the project would be a good balance between faculty members' workloads and ensuring student success.

Both Jaime Cantu (UTA) and Christoph Csallner (UTA) require their student teams to present before the class three times over the duration of the projects. Other class members and 2-3 library/makerspace staff attend each presentation and provide formative feedback. A best practice recommendation would be for faculty to schedule at least one mid-project critique/presentation and a final critique/presentation, each with library/makerspace staff and/or other expert participation.

Several faculty members suggest spending time observing their students in the makerspace in order observe student activities and engagement, and be able to compare their final projects and their journals to what they personally witnessed among their students. This would provide opportunities for direct and formative assessment.

Lastly, for courses where students work in teams, students should complete peer evaluations where they provided feedback on their team members' communication, contributions, etc.

22. Next Steps

The Maker Literacies program team at UTA Libraries endeavors to continue to expand and improve upon the pilot implementation of the program by focusing on two areas: professional development and assessment of student learning. In collaboration with the program leads at our partner institutions, we have submitted another grant proposal to IMLS for a second National Leadership Grant for Libraries, this time as a three-year project grant as opposed to this one-year planning grant.

Professional Development

Based on the faculty, librarian, and makerspace staff feedback gathered during this planning grant, grant personnel recommend the creation of comprehensive professional development content focused on pedagogical growth for

librarians and makerspace staff involved in teaching and learning activities. This would be two-pronged: first, strengthen librarian and makerspace staff curriculum development competencies and second, train librarians and faculty members on use of makerspace equipment and software.

Assessment of Student Learning

With the final revisions to the list of maker competencies, we will now revise the pre- and post-self-assessment surveys to align with the new competencies and to incorporate best practices in survey design that we've learned over the course of the pilot program, including survey validation and response option configuration.

To supplement the surveys and to assist faculty members with formative assessment, there is a need for adaptable rubrics for each of the competencies. These rubrics would not only help better define and articulate the competencies for faculty (addressing the incongruence we saw in the case studies), but also help faculty to better articulate the student learning achieved through the maker projects in their courses.

23. Appendices

Many of the products that resulted from these grant-funded activities, including final evaluation reports and instruments; research findings, publications, and data; curriculum guides, workbooks, manuals, and other learning resources; published announcements, news releases, articles, and other media coverage can all be found at our program website, https://library.uta.edu/makerliteracies. We have included in this section only those appendices referenced herein. Annotated citations and links to all publications and online resources that resulted from this work are available on our website, for others who wish to learn more about the project or use its resources.

Appendix 1: Partner Selection Criteria

The following is a list of all the criteria we used in our scoring rubric. Those marked "not scored" were not included in the scoring and sorting, but were given consideration post-sorting to identify any circumstances that present special benefits to this work, or lead to broader diversity of participants.

Criteria	How Scored
Public/Private	not scored
Enrollment size	not scored
Land Grant y/n	not scored
Makerspace in library?	y=3, n=1
Library is discipline specific?	n/a=1, y=2, n=3
Serves all disciplines?	Y=3, n=1
Extended hours (late PM, overnight, early AM)	y = 3, n = 1
Staff model	not scored
Meets minimum equipment requirement[1]	y=3, n=2
Years Providing Makerspace Services	0-1 year = 1, 1-3 year = 2, 3+ years = 3
Geographic region	not scored
Student demographics	not scored
Is already integrating into curriculum y/n	y, formally = 3, y, informally = 2, n = 1
Has already developed or begun developing learning outcomes	y = 3, maybe[2] = 2, n = 1
Library Engagement	Likert scale 1-5, where 1=high, 5=low
Makerspace Engagement	Likert scale 1-5, where 1=high, 5=low
Faculty Engagement	Likert scale 1-5, where 1=high, 5=low
# of Faculty Willing to Participate	1 point per willing faculty member
Faculty Disciplines	not scored
Makerspace Capacity	not scored
Experience with Assessing Learning	y=3, n=1
Experience Partnering on Projects w/ Other Univ.	y=3, n=1
Special considerations	not scored

A detailed description of our partner selection process is included in: Wallace, Martin K., Gretchen Trkay, Katie Musick Peery, Morgan Chivers, and Tara Radniecki. "Maker Competencies and the Undergraduate Curriculum." Paper presented at the International Symposium on Academic Makerspaces, Stanford, CA, August 3-5, 2018. https://rc.library.uta.edu/uta-ir/handle/10106/27518

[1] The minimum equipment requirement was that the makerspace provides access to and support for two or more types of making, i.e. 3D printing *and* sewing.

[2] The "maybe" option indicates a strong commitment to undergraduate curriculum where it would be hard to NOT have developed some learning outcomes, but where we can find no explicit statement about this, including from questionnaire.

Appendix 2: Beta Maker Competencies List

The "Maker-Literate" student:

1. Identifies the need to invent, design, fabricate, build, repurpose or repair some "thing" in order to express an idea or emotion, or to solve a problem.
    a. Recognizes unmet needs that may be filled by making
    b. Expresses curiosity about how things are made and how they work
    c. "Hacks" and "tinkers" to learn how things are made and how they work
    d. Evaluates the costs & benefits of making as an alternative to buying or hiring
2. Applies design praxis
    a. Defines the problem
    b. Analyzes the problem and breaks it into component parts acquires reliable and relevant background information identifies stakeholders
    c. Specifies project requirements
    d. Identifies and works effectively within project constraints, be they financial, temporal, proximal, or material
    e. Brainstorms for a variety of solutions & chooses the best one
    f. Evaluates the costs & benefits of using off-the-shelf parts or kits as opposed to making from scratch
    g. Creates and tests prototypes
    h. Revises and modifies prototype design over multiple iterations
    i. Takes intelligent risks and learns from failures
3. Demonstrates time management best practices
    a. Outlines project milestones and identifies dependencies
    b. Constructs critical paths
    c. Builds in extra time to allow for multiple prototype iterations
4. Assembles effective teams
    a. Recognizes opportunities to collaborate with others
    b. Evaluates the costs & benefits of "Doing-it-Together" (DIT) vs. "Doing-it-Yourself" (DIY)
    c. Seeks team members with skills appropriate for specific project requirements
    d. Joins a team where his/her skills are sought and valued
    e. Solicits advice, knowledge and specific skills succinctly from experts
5. Employs effective knowledge management practices
    a. Communicates clearly with team members and stakeholders
    b. Restates technical and "maker" jargon in plain English documents work clearly
    c. Uses version control to manage project outputs and documentation
    d. Preserves project outputs and documentation for long-term access
6. Assesses the availability of tools
    a. Elects the best tools for the job
    b. Acquires the necessary tools or revises project to conform to tool availability
    c. Seeks alternate tools when a required tool is not available
    d. Creates necessary tools that can't be acquired or when an alternate is not an option
7. Assesses the availability of materials
    a. Selects the best materials for the job
    b. Acquires the necessary materials or revises project to conform to materials availability
    c. Seeks alternate materials when a required material is not available
8. Demonstrates understanding of digital fabrication process
    a. Recognizes additive and subtractive fabrication techniques
    b. Applies 3D modeling principles
    c. Creates 3D models using appropriate software
9. Understands many of the ethical, legal and socio-economic issues surrounding making

a. Demonstrates an understanding of intellectual property rights and protections
b. Identifies project outputs that may be protectable by trade secret, patent, trademark or copyright
c. Compares the costs & benefits of seeking intellectual property protections v. making project outputs open and freely available to others
d. Evaluates the costs & benefits of open source and proprietary systems
e. Recognizes and respects the intellectual property rights of other makers

10. Employs safety precautions
    a. Seeks training for dangerous equipment and materials
    b. Wears personal protective gear when appropriate
    c. Teaches safety precautions to others
11. Transfers knowledge gained into workforce, community, and real world situations
    a. Teaches what he/she knows to less experienced makers

Appendix 3: Revised Maker Competencies List (Revised December 2018)

Competencies

Makers will:

Ideate

1) Identify the need to invent, design, fabricate, build, repurpose, repair, or create a new derivative of some "thing" in order to express an idea or emotion, to solve a problem, and/or teach a concept
    a. recognize unmet needs that may be filled by making
    b. tinker and hack to learn how things are made and how they work
    c. evaluate the costs and benefits of making as an alternative to buying or hiring
    d. investigate how others have approached similar situations
2) Analyze the idea, question, and/or problem
    a. define the idea, question, and/or problem
    b. break the idea, question, and/or problem into its constituent parts
    c. question assumptions
3) Explore the idea, question, and/or problem and potential solutions
    a. garner input from stakeholders and peers
    b. research existing relevant products and ideas
    c. brainstorm a variety of solutions and pursue the most promising one
    d. evaluate the costs and benefits of using off-the-shelf parts or kits as opposed to making from scratch

Create

4) Operate safely
    a. seek training and information on dangerous equipment and materials
    b. ascertain applicable technical standards and safety codes
    c. wear personal protective gear when appropriate
    d. reinforce safety precautions with others
    e. accustom self with location-specific emergency procedures, egress and disaster plans
    f. observe safety procedures in the event a person(s) is impaired or injured
    g. transfer safety principles gleaned in training to broader contexts
5) Assess the availability and appropriateness of tools and materials
    a. research various equipment and materials to determine limitations and suitability for a specific application
    b. choose the most appropriate tools and materials (physical, digital, and rhetorical) for the job
    c. acquire the necessary tools and materials
    d. investigate alternate tools and materials when a desired tool or material is not available
    e. fabricate necessary tools, reimagine material choices, develop alternate workflows, and/or revise project scope when alternative tools or materials are not available
6) Produce prototypes
    a. determine the method of creation most suited to the project
    b. gain confidence with technologies and processes required for creation
    c. specify functional requirements for prototype vs desired finished product
    d. divide design into individual components to facilitate testing
    e. document design process
7) Utilize iterative design principles
    a. apply measurable criteria to determine whether creation meets needs

b. revise and modify prototype design over multiple iterations
c. gather prototype feedback and input from stakeholders and mentors
d. rework design to include insights from feedback
e. take intelligent risks, use trial and error, and learn from failures

Manage

8) Develop a project plan
    a. identify who the relevant stakeholders are
    b. specify actionable and measurable project goals and requirements
    c. utilize time management and project management tools
    d. outline project milestones, including sequential action items
    e. anticipate time for multiple prototype iterations
    f. work effectively within project constraints, be they financial, material, spatial, and/or temporal
9) Assemble effective teams
    a. recognize opportunities to collaborate with others who provide diverse experiences and perspectives
    b. gauge the costs & benefits of "Doing-it-Yourself" (DIY) or "Doing-it-Together" (DIT)
    c. recruit team members with diverse skills appropriate for specific project requirements
    d. join a team where one's skills are sought and valued
    e. solicit advice, knowledge and specific skills from experts
10) Collaborate effectively with team members and stakeholders
    a. listen to others
    b. learn from and with others
    c. communicate respectfully and clearly with team members and stakeholders
    d. follow through on team commitments and responsibilities
    e. practice accountability both personally and with team members
    f. appraise contributions to the success of the team
11) Employ effective knowledge management practices
    a. restate technical and maker jargon for the layperson
    b. document steps clearly with sufficient detail for others to follow and replicate workflows
    c. use version control to manage project outputs and documentation
    d. preserve project outputs and documentation for long-term access

Share

12) Apply knowledge gained into other disciplines, workforce, and community
    a. teach skills and share insights with other makers
    b. recognize and cultivate transferrable skills
    c. transfer knowledge, skills, and methods of inquiry across disciplines and activities
    d. familiarize self with skillsets of others
    e. connect those seeking to learn something with those who have relevant experience
13) Be mindful of the spectrum of cultural, economic, environmental, and social issues surrounding making
    a. express awareness of diversity and inclusion when identifying unmet needs
    b. consider sustainability when making, including upcycling and recycling materials
    c. scrutinize the ethical implications of making
14) Understand many of the legal issues surrounding making
    a. demonstrate an understanding of intellectual property rights and protections
    b. weigh the costs & benefits of seeking intellectual property protections v. making project outputs open and freely available to others

c. examine the potential viability of both proprietary and open source systems to adopt/adapt
d. respect the intellectual property rights of other makers

15) Pursue entrepreneurial opportunities
    a. perform thorough market research for competing products and capacity for monetization
    b. identify project outputs that may be protectable by trade secret, patent, trademark or copyright
    c. project costs of mass production and requisite economies of scale for return on investment
    d. refine financial plan for variable scenarios

Dispositions & Values

Makers:

- Construct knowledge and understanding through doing.
- Reflect on what they have learned by making.
- Convey curiosity about how things work, how things are made, why they have been made that way, and how they might be improved.
- Celebrate opportunities to share skills, knowledge, ideas, and creations to benefit a broader community.
- Practice persistence through the problem solving and iterative design process.
- Engage enthusiastically in opportunities to learn.
- Exhibit appropriate confidence in their ability to ideate, create, and problem solve.
- Embrace risk and innovation.
- Value collaboration and diverse perspective and experiences.
- Appreciate openness and sharing.
- Comprehend that the objects one makes are tangible forms of embodied knowledge.

Appendix 4: Participant Feedback Survey Questions

1. Role in Project

- ○ Subject faculty
- ○ Librarian
- ○ Maker space staff

2. How many courses did you work with for this grant? [Display This Question: If Role in Project = Librarian Or Role in Project = Maker space staff]

- ○ 1
- ○ 2
- ○ 3
- ○ 4

3. University Name
4. Course Name and Description. [Repeats for as many courses as indicated in #2.]
5. Number of Students Enrolled in Course [Repeats for as many courses as indicated in #2.]
6. Please list your learning outcomes for the maker-based project. For those who worked with more than one grant-related course, please list the outcomes for all of the courses with which you worked.
7. How easily did the beta maker competencies map to your (or your faculty member's) course(s) or assignment learning outcomes?

- ○ Very easy to map
- ○ Easy to map
- ○ Neutral
- ○ Difficult to map
- ○ Very difficult to map

8. Please explain why you have given this rating. Give details about what made it easy and/or difficult and what you would have done differently.
9. How well did the beta maker competencies represent the transferable skills you want students to learn?

- ○ Very well
- ○ Moderately well
- ○ Slightly well
- ○ Not well

10. Please explain why you have given this rating. Give details about how the beta maker competencies were relatable to your course and how they were not.

11. What competencies would you add that are not currently represented in the beta maker competencies list? Please include defining characteristics for suggested competencies.

12. Do you have suggestions for how to improve the following competency? [#12 and #13 repeat in similar fashion for all 11 competencies.]

Competency 1: Identifies the need to invent, design, fabricate, build, repurpose or repair some "thing" in order to express an idea or emotion, or to solve a problem

—recognizes unmet needs that may be filled by making
—expresses curiosity about how things are made and how they work
—"hacks" and "tinkers" to learn how things are made and how they work
—evaluates the costs & benefits of making as an alternative to buying or hiring

- ○ Yes
- ○ No

13. How would you improve Competency 1? [Display This Question: If Do you have suggestions for how to improve the following competency? Competency 1: Identifies th... = Yes.]

14. Describe your maker curricula - please include a description of the assignment and learning activities. [Repeats for as many courses as indicated in #2.]

15. Please describe how you assessed student learning related to the maker curricula. [Repeats for as many courses as indicated in #2.]

16. How easy was it to measure student learning mapped to the beta competencies? For those who worked with more than one grant-related course, please rate the competencies included in all of the courses with which you worked.

	Very easy	Easy	Neutral	Difficult	Very difficult	Did not assess in course
Competency 1	○	○	○	○	○	○
Repeats for Competency 2, 3, etc.	○	○	○	○	○	○

17. Please explain why you have given this rating for Competency 1. Give details about what made it easy and/or difficult and what you would have done differently. [Repeat for each competency rated in #16.]

18. What assessment strategies were most effective for measuring student learning? Why do you think the strategies were successful?

19. What assessment strategies were least effective for measuring student learning? Why do you think the strategies were unsuccessful?

20. What additional feedback to you have about the assessability of the beta competencies?

21. Please describe how the faculty, librarian, and/or maker space staff collaborated to create maker-based learning experiences for students.

22. Was the collaboration successful?

- ○ Yes
- ○ No

23. Please explain why you have responded this way.

24. What tips and processes would you recommend for faculty, librarians, and maker space staff collaborating to create maker-based learning experiences for students?

25. What professional development do you think is required for faculty, librarians, and/or maker space staff so that they can confidently and capably create maker-based learning experiences for students?

26. What else would you like the grant team to know about your work on this project?

27. The library is better prepared to collaborate with faculty to incorporate maker-based competencies into curricula. [Display This Question: If Role in Project = Librarian Or Role in Project = Maker space staff.]

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

28. My library is better able to engage faculty with maker-based learning and competencies. [Display This Question: If Role in Project = Librarian Or Role in Project = Maker space staff.]

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

29. My library is better prepared to develop and maintain on-going relationships with faculty related to maker-based learning. [Display This Question: If Role in Project = Librarian Or Role in Project = Maker space staff.]

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

30. My library is better prepared to share knowledge and other resources as an active contributor to problem solving related to maker-based learning. [Display This Question: If Role in Project = Librarian Or Role in Project = Maker space staff.]

- ○ Strongly agree
- ○ Somewhat agree

- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

31. The library offers programs, services, or resources that address community needs related to maker-based learning. [Display This Question: If Role in Project = Subject faculty.]

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

32. The library is an active contributor to problem solving related to maker-based learning. [Display This Question: If Role in Project = Subject faculty.]

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

33. We will be applying for an IMLS project grant that expands on this planning grant. The due date for the 2-page preliminary proposal is September 1st and will be written in late July/early August. Are you interested in partnering for the project grant? [Display This Question: If Role in Project = Librarian.]

- ○ Yes
- ○ No

Appendix 5: Presentations and Publications Resulting from this Work

Wallace, M. K., Trkay, G., Chivers, M., Musick Peery, K., & Radniecki, T. (2018). List of Maker Competencies, Including Preamble and Acknowledgments (LG-97-17-0010-17-competencies). Arlington, TX: University of Texas at Arlington Libraries. https://rc.library.uta.edu/uta-ir/handle/10106/27634

Cantu, J., & Wallace, M. K. (2018, October 17-20). *Developing student learning outcome metrics for makerspaces: A STEM pilot course*. Paper presented at the American Society for Engineering Management 2018 International Annual Conference, Coeur d'Alene, ID. https://rc.library.uta.edu/uta-ir/handle/10106/27569

Wallace, M. K., Trkay, G., Musick Peery, K., Chivers, M., & Radniecki, T. (2018, August 3-5). *Maker competencies and the undergraduate curriculum*. Paper presented at the 2018 International Symposium on Academic Makerspaces, Stanford, CA. https://rc.library.uta.edu/uta-ir/handle/10106/27518

Wallace, M. K., Trkay, G., Musick Peery, K., & Chivers, M. (2017, September 24-27). *Making Maker Literacies: Integrating Academic Library Makerspaces into the Undergraduate Curriculum*. Paper presented at the 2017 International Symposium on Academic Makerspaces, Cleveland, OH. https://rc.library.uta.edu/uta-ir/handle/10106/27518