List of Maker Competencies (Revised December 2018)

Maker Competencies, Defined

As the label implies, maker competencies are the skills, talents and dispositions that one acquires or improves upon while problem-solving and working on projects in makerspaces or similar learning environments. However, while learners can develop any number of technology-specific competencies while working in makerspaces—dependent on the types of technology made available within the specific makerspace—this list of competencies is better defined as the higher-level, technology-agnostic, transferrable skills and talents that one may acquire or strengthen when working in makerspaces. A quick review of the list of competencies will reveal no mention of 3D printers, Arduinos, or any of the other popular technologies commonly found in makerspaces today; what one will find are competencies related to collaboration, communication, critical thinking, design thinking, and project management. These competencies may be considered universal in their application across disciplines and industries, are highly sought by employers, and are often referred to as 21st Century Competencies, Soft Skills, or otherwise technology-independent aptitudes.

History of the List of Maker Competencies

Development of this list of maker competencies took place over a series of phases between March 2016 and December 2018. In March 2016, a Maker Literacies Task Force was formed at the University of Texas at Arlington (UTA), comprised of library staff, makerspace staff, and faculty members from various subject disciplines. The task was to develop a program for integrating the UTA FabLab (UTA's academic library makerspace) into the undergraduate curriculum. The goal of this early work was to identify a set of cross-disciplinary transferrable skills that undergraduate students could acquire in makerspaces and later apply in graduate school or in the work force. The Task Force culminated with a beta version of the list of competencies, along with a program for formally integrating the FabLab into the curriculum, exposing students to a learning environment that nurtures these competencies. The beta competencies were based on faculty interests, a review of the relevant literature, attendance at Maker Faires and similar conferences, interviews with makers (teachers and learners alike) at Dallas-Fort Worth-area makerspaces, and direct observation of those working in makerspaces.

Over the fall 2016 semester, faculty from a diverse range of subject disciplines–some of whom served on the Task Force—began piloting the program in their courses with an eye toward curriculum design practices that integrated the competencies into their lesson planning. The Task Force, having successfully achieved its goals, was discharged in August 2017. The pilot program created by the Task Force continued through spring 2018, now under the direction of a four-member team of UTA Libraries and FabLab staff. This team, in its present incarnation, includes the Director of the UTA FabLab, the Head of UTA Libraries' Experiential Learning and Undergraduate Success department, the Maker Literacies Librarian, and the FabLab Librarian, as its constituent members. The Maker Literacies Program Team is responsible for coordinating, assessing, growing and continually improving the program.

In spring 2017, the Maker Literacies Program Team was awarded a grant (National Leadership Grants for Libraries #LG-97-17-0010-17) from the Institute of Museum and Library Services (IMLS), with which they were able to pilot the program at four additional academic library makerspaces in the spring 2018 semester: Boise State University (BSU), University of Massachusetts Amherst (UMass), University of Nevada, Reno (UNR), and University of North Carolina at Chapel Hill (UNC). During this phase, the

Engineering Librarian at UNR joined UTA's Maker Literacies Program Team as an outside expert and participated in all aspects of the grant-related work, in addition to coordinating the pilot program at the UNR DeLaMare Library makerspace.

One of the goals for the IMLS grant-funded work was to revise and improve the beta-phase list of maker competencies. During the initial pilot phase at UTA, the Task Force gathered feedback from participating faculty regarding the challenges of integrating the FabLab into their courses, usefulness of the list of maker competencies in planning their curriculum, and effectiveness of the Maker Literacies Program, including evidence of student learning; likewise, during the IMLS-funded partnership phase, the grant team gathered feedback from librarians, makerspace staff and faculty participants from all five partner sites covering those same topics. Participants from both phases provided a tremendous amount of actionable feedback about the usefulness of the beta-phase list of competencies, including recommendations for additions to the list. After a thorough review of all feedback, the grant team revised and publicly released this finalized list of maker competencies in December 2018.

How to Use the List of Maker Competencies

The list of maker competencies was developed specifically as a lesson-planning aid for faculty of undergraduate courses seeking to integrate academic library makerspaces into their curriculum. For sure, the list can be used more broadly than this context. The competencies could apply to any semi-structured, formal or informal learning environment where learners apply hands-on problem solving in a creative studio-style space and where teachers wish to gauge the development of competencies in their students.

The list was modeled largely on the Association for College and Research Libraries (ACRL) *Information Literacy Competency Standards for Higher Education* (2000) and can be used in much the same way. The ACRL standards opened the door for hundreds, if not thousands, of curriculum-embedded information literacy programs across the nation's universities. Due to the far-reaching success of the ACRL standards, and because the developers of the Maker Literacies Program—for which this list forms the foundation—have experience with the ACRL standards and are now seeking to embed academic library makerspaces into the curriculum, the ACRL model was the ideal model to borrow from.

Items in the competencies list are designed to be mapped to existing and/or adopted as new student learning outcomes (SLOs) in courses that emphasize the types of transferrable skills exemplified by the list. The items should be used just like any other SLOs in the curriculum-planning process. This usually begins with brainstorming for a list of things an instructor expects students to learn by taking their course. Narrow this list to a set of realistically achievable outcomes, and then consult the List of Maker Competencies to see if any items in the list correspond to the instructor's desired SLOs. In some cases, a broad category itself may be suitable as an SLO (categories are numbered 1-15 in the list); in other cases, it may be best to select one or more of the category's dimensions as SLOs (dimensions are indented beneath each category and labeled a-f). The list of competencies is not static and can be flexibly adapted to the instructor's needs.

Once Maker Competencies have been mapped to corresponding SLO counterparts, the next step is to design curriculum with the SLOs in mind. Assignments should include components that require students to utilize the makerspace while also reinforcing the SLOs. In the case of the Maker Literacies Program, these usually materialize as projects (individual or team-based) that require students to create an object in the makerspace; but often the assignment may take a different angle than making an object, or the object might not be something physically tangible as most of current making suggests. These things can be software for makerspace operations management, in the case of a computer science course, or a technical manual, in the case of an English course. In short, the term "making" should be interpreted broadly. While designing assignments, it is imperative that instructors receive consultation from makerspace staff. Instructors should inquire about the types of equipment available in the makerspace, and the makerspace's staff and space capacity for providing services to the class. Knowing the benefits *and* limitations of the makerspace will help the instructor develop specifications for the assignment.

The last step is to develop assessment tools for measuring SLOs. These often take the form of analytical rubrics in combination with oral or written reflections from students. In short, the assessment tool needs to be designed to capture student competence gained by completing the assignment. In many situations, it may benefit the instructor to develop assessment tools before designing the assignment itself; this method is called "Backward Design" and is very common in competencies-based and online education, where assessment takes center stage and assignments are carefully designed to insure that assessment can be appropriately conducted. Whether employing traditional or backward design, the three steps described here are the essentials for good lesson planning, with well-crafted SLOs at the center of it all.

The Maker Literacies Program website (https://libraries.uta.edu/makerliteracies) includes sample lesson plans from many faculty who have participated in the Program. The lesson plans are released with Creative Commons licenses so that others may use them. As the Maker Literacies Program continues to grow, so will the archive of lesson plans.

Avoiding Jargon in the List of Maker Competencies

As with any domain-specific technical document such as this, jargon is almost unavoidable. The Maker Literacies Program Team has taken great care to eliminate extraneous jargon and to clarify unavoidable jargon by placing it within ample context for readers to gain understanding of its meaning.

Feedback from the Program's beta-testing phase revealed the following four terms to be problematic jargon: Critical Path, Hack, Tinker, and Version Control. "Critical Path," originally a dimension of the beta-phase Time Management category, has been expanded as its own competency in the revised list: "Develop a project plan." The term "Critical Path" does not appear anywhere in the list, but the "Develop a project plan" competency, along with its dimensions, is an extrapolation of the meaning of "Critical Path."

The terms "Hack" and "Tinker" remain in the list. For the purposes of this document, both of these refer to the informal, exploratory acts of physical inquiry that students pursue in order to better understand a process or object. Hacking refers to the act of deconstructing something to figure out how it works, then re-building it, often tweaking its original design for a new purpose. Tinkering refers to the trial-and-error process of making something out of serendipitously available parts and materials, without a plan, simply for the sake of learning how different things can be combined.

Lastly, the term "Version Control" has been expounded upon in the context of the "Employ effective knowledge management practices" competency. Version control is any system or method for keeping track of the various versions and/or iterations of a product or document.

List of Maker Competencies

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.

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