Full Paper: A Makerspace Project for New Transfer Students

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Morgan Chivers graduated from San Jose State University (2011) after spending a full decade earning four simultaneously conferred degrees and five minors: BA History, BA Global Studies, BFA Photography, and BFA Spatial Arts, with minors in Anthropology, Music, Religious Studies, German, and Environmental Studies. UTA's glass program lured this Californian to Texas; Morgan earned an MFA in Glass / Intermedia (2015) with conceptually-rooted, experimental artwork often involving digital fabrication. He joined the FabLab team shortly thereafter as a Technician, and now serves as FabLab Librarian & Artist in Residence, helping to train student employees, liaison to A+AH Department, integrate making into curriculum across this beautifully diverse campus, and to present the UTA FabLab's innovative work at professional conferences and symposia.

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Introduction

In the Fall 2018 semester, The University of Texas at Arlington (UTA) began teaching a first year experience course for all transfer students entering the College of Engineering (COE) with more than 24 credit hours. The one-credit hour, one-contact hour course was a response to lower than desired retention rates. Transfer students to the COE come with a vast array of academic backgrounds and experiences. Many of our transfer students work part-time, or even full-time jobs, many commute significant distances, and many are the main caretakers of family members. Scheduling courses can be difficult even for students without these constraints. A one-hour time block was believed to be more convenient for students to fit into their first-semester schedules, which often include blocks of lab time.

A committee of COE faculty was assembled to develop the course, which was given the designation ENGR 1101. After reexamining what could be accomplished in fifteen 50-minute sessions, and what would be most useful to transfer students, the committee decided on the following learning objectives for ENGR 1101:

- Work on a design project in multi-disciplinary teams
- Develop an engineering entrepreneurship mindset
- Explain the basis for and importance of engineering ethics
- Describe the different engineering disciplines
- Recognize and utilize academic and personal student resources available at UTA

Team Project

The students had a choice of four design projects. Their design project choices and the number of students who chose each project are shown in Table 1. As a note, students who did not fill in the design choice survey by the due date were automatically assigned the Dean's Challenge, which greatly inflated the number of students assigned that project.

Table 1: ENGR 1101 Design Project Choices

Project Title	**Project Description**	**Students**
ASEE Video	Create a storyboard for the ASEE 125th Anniversary Video Contest	15
Dean's Challenge	Develop a concept to help Arlington become a smart city.	151
FabLab Project	Design and build a UTA branded item using at least two pieces of equipment in UTA's makerspace.	175
NAE Grand Challenge	Research a concept related to one of the NAE Grand Challenges	82

For the ASEE Video project, students were required to create a storyboard for a 90-second video exploring what engineering education will look like 25 years from now in 2043. Students were

required to draw shots, describe settings and props, write dialog, and estimate durations for each scene in the video.

The Dean's Challenge and the NAE Grand Challenge projects required students to either write a report or record a presentation of their concepts. They had to research the NAE Grand Challenges or the idea of a smart city, come up with a concept related to the area of their choice, and research existing systems and/or technologies. They were asked to advance one of those systems or technologies in a small way, consider the feasibility of their concept, and explain how it would add value to the world.

The most popular among students was the FabLab project. It required students to not only design, but also build an object. Students had to learn about the equipment available to them, decide which equipment they wanted to use for their project, design a UTA branded item, learn how to use the equipment required for their project, and then actually create the item. Students turned in a blog of the design and build process. They were also required to include a section in their blog reflecting on lessons learned. The full assignment prompt is available on the FabLab's Maker Literacies website. [1]

No matter which project was chosen, students were required to work in assigned groups of five. Students wrote weekly reflections on the team's progress as well as any teamwork struggles. Final project deliverables were all team-based.

Maker Competencies

Between 2015 and 2018, UTA Libraries assembled a Maker Literacies Task Force of librarians and faculty members from various subject disciplines across campus to work on the development of a list of skills, talents, and dispositions that one acquires or improves upon while problem-solving and completing projects in makerspaces or similar learning environments.
All students who participated in the Maker Literacies research through Fall 2018 were assessed on the beta-competencies; Table 2 lists the latest version of the Maker Competencies developed at UTA. [2]

Pre- and post-project surveys were given to transfer students enrolled in the class in order to assess their self-perceived abilities related to beta-competencies 1 and 11. Descriptive data of survey results for ENGR 1101:

- Sample size: 23, self-selected
- Number who completed FabLab project: 14
- Number who completed another project: 9

Competencies 1 and 11 each have four scales each. All scales range from 1-5, with 1 being no competency and 5 being high competency. A student's score is calculated by averaging the four scales together. Aggregate scores are calculated by averaging all student scores together; the outcome comparisons in the graphs below use aggregate scores.

Table 2: Maker Competencies

Category	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.
	2. Analyze the idea, question, and/or problem.
	3. Explore the idea, question, and/or problem and potential solutions.
Create	4. Operate safely.
	5. Assess the availability and appropriateness of tools and materials.
	6. Produce prototypes.
	7. Utilize iterative design principles.
Manage	8. Develop a project plan.
	9. Assemble effective teams.
	10. Collaborate effectively with team members and stakeholders.
	11. Employ effective knowledge management practices.
Share	12. Apply knowledge gained into other disciplines, workforce, and community.
	13. Be mindful of the spectrum of cultural, economic, environmental, and social issues surrounding making.
	14. Understand many of the legal issues surrounding making.
	15. Pursue entrepreneurial opportunities.

Competency 1 assesses students on their ability to identify 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. Specifically, students were asked to rate their competencies in the four areas:

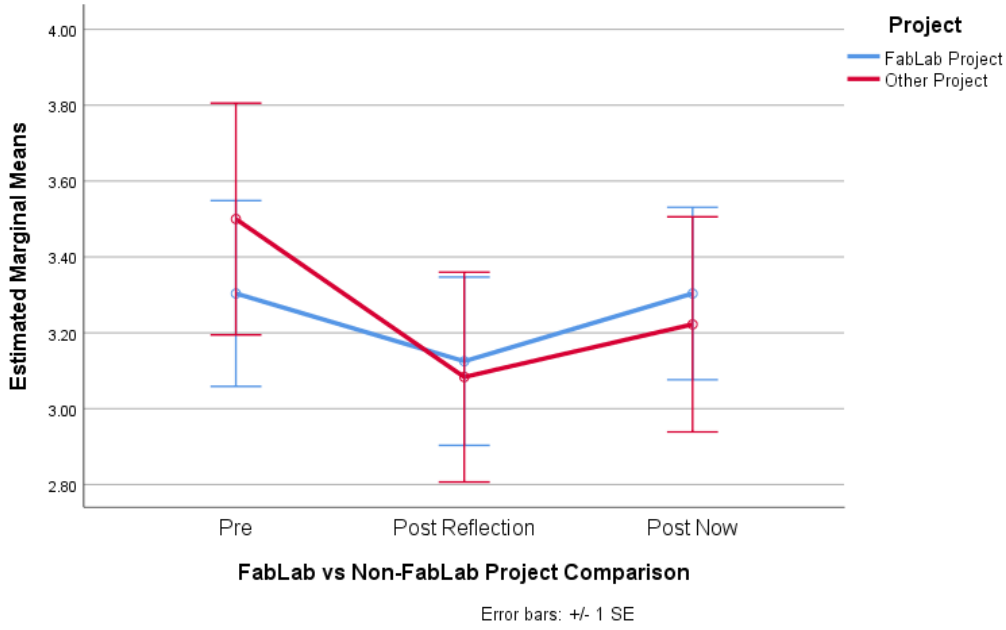
1.a. Recognizes unmet needs that may be filled by making
1.b. Expresses curiosity about how things are made and how they work
1.c. "Hacks" and "tinkers" to learn how things are made and how they work
1.d. Evaluates the costs & benefits of making as an alternative to buying or hiring

Students who chose the FabLab project overestimated their competency by 5.6% difference, and gained 5.7% increase in their ability to identify the need to make. In contrast, students who chose any of the other projects overestimated their competency by 12.7% difference, and gained 4.5% increase in their ability to identify the need to make. A graph of the survey result comparisons for Competency 1 is shown in Graph 1.

Competency 11 requires makers to employ effective knowledge management practices. Specifically, students were asked to rate the competencies in four areas related to this competency:

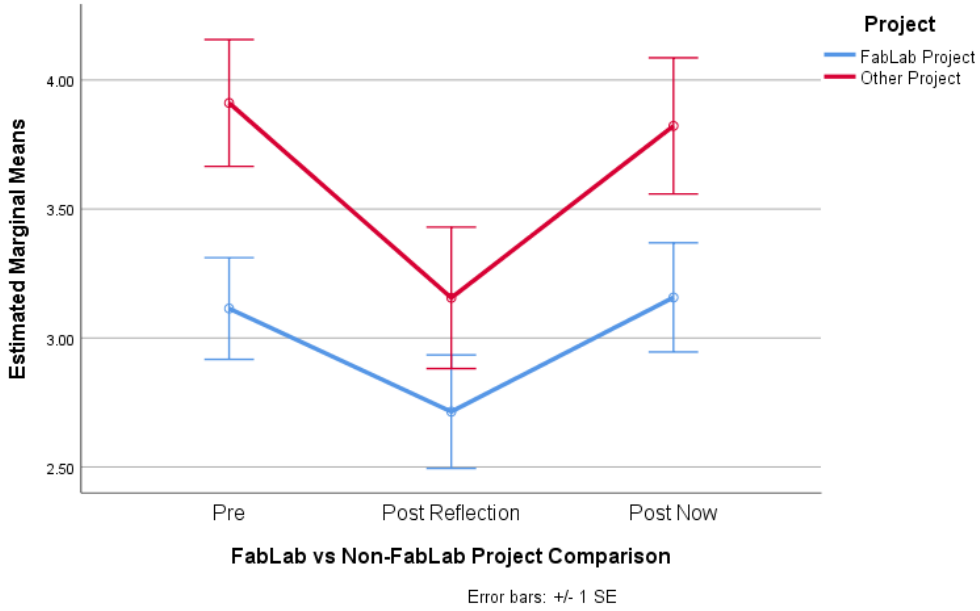
11..a. Communicates clearly with team members and stakeholders
11.b. Restates technical and "maker" jargon in plain English documents work clearly
11.c. Uses version control to manage project outputs and documentation
11.d. Preserves project outputs and documentation for long-term access

Graph 1. Project Comparison of Competency 1



Students who chose the FabLab project overestimated their competency by 13.7% difference, and gained 16.3% increase in their ability to employ effective knowledge management practices. In contrast, students who chose a different project overestimated their competency by 21.4% difference, and gained 21.1% increase in their ability to employ effective knowledge management practices. A graph of the project comparisons for Competency 11 is shown in Graph 2.

Graph 2: Project Comparison for Competency 11



FabLab Project - Student Self-Reported Lessons Learned

As part of their blogs, students were asked to list some of the lessons they learned by doing the project. Some of their statements are listed in Table 2.

Table 2: Student Written FabLab Project Lessons Learned

"For some of us, doing this project made us discover a new passion. It was an awesome and meaningful experience for us which helped to endurably connect the digital and physical world economically."
"Having 100% attendance for every meeting is not always possible, so mobile and email communication is the key."
"Making a design, assembling, and simulating on Solid Works is different from a printed object through a 3D printer. There are many more things that need to be taken into account. Such as printers add 5 to 2mm to a surface depending on what is being printed."
"The training process in the FabLab showed us how easy and accessible all sorts of equipment, tools, and technology is actually available to us. As UTA students, we have multiple types of resources on campus that we can and should be utilizing as we do our studies."
"We initially thought the whole process of training and creating an item was going to be more difficult and time consuming than it turned out to be."
"We learned that designing and fabricating as a team is an intricate and fun experience."
"We started this project out as five transfer students who came from different backgrounds and were pursuing different majors. But the past couple of weeks where we all worked together, we all learned new things."

FabLab Project - Faculty and Staff Lessons Learned

After grading over 60 projects, it became apparent that some project types were more suited to the course learning objectives than others. The teams that selected to work on the FabLab project demonstrated superior teamwork to the teams who selected the other project options, as observed by the course professor. It was clear from the blogs that teams really did need to work together to accomplish the FabLab project tasks. Pictures showed most, if not all, team members working together in the library. The other project types had tasks which much more easily lent themselves to divide and conquer assignments between task members. This was obvious from the reports, which tended to lack cohesion between sections.

Judging by the number and proportion of students who selected the FabLab Project, the prospect of working with accessible digital fabrication equipment is exciting for incoming engineering students. This is perhaps a relatively straightforward observation, though our experience in guiding the students through the semester assignment held some unforeseen surprises.

In the assignment prompt, students were told they would need to receive training from FabLab staff before using the machines. The UTA FabLab is set up to remove as many barriers to access as is feasible, so the vast majority of equipment is available for students to use on a walk-in, first-come/first-served basis. Trained student staff meet the learner at their need to provide

assistance setting up files and with operating the 3D printers, laser cutters, embroidery machine, printmaking tools, etc. There is also a ShopRoom in the FabLab, which requires much more extensive training available by appointment only, limited to 5 learners at a time. Many students were confused by the use of the word "training" and mistakenly thought they were required to attend the ShopRoom trainings prior to using the 3D printers or laser cutters. This overloaded the capacity of the FabLab full-time staff providing ShopRoom trainings and frustrated some students whose schedules did not allow them the flexibility to attend all the ShopRoom trainings and who were under the impression that they were required to do so. Coordination between faculty and FabLab staff cleared up the expectations and requirements for equipment use, both for the latter part of the fall semester and from the outset of the spring 2019 semester.

Several of the students who chose to work on the FabLab project needed to be instructed on the concept of plagiarizing designs. The maker community prides itself on it free and open sharing of designs, instructions, and strategies. There are several websites where designs appropriate for 3-D printing can be downloaded and edited or used as is. There was no requirement that students design every component of their project from scratch, so while in and of itself the use of a downloaded file was fine for this project, many groups failed to cite the source of their design or even mention that it was a downloaded design. When asked about it, students didn't seem to know that anything other than cut and pasted paragraphs needed to be cited. This was an especially important conversation to have with a class of students in their first semester at UTA, as it presented an opportunity to impress upon them how crucial the culture of academic integrity is to a research university, even in a fun assignment. Future semesters will include specific instructions on how and why to cite design sources.

References

[1] "Maker Literacies Lesson Plans," University of Texas at Arlington, 12 2018. [Online]. Available: https://library.uta.edu/makerliteracies/lesson-plans/entrance-engineering-transfer-students. [Accessed 26 6 2019].

[2] M. Wallace, "Maker literacies: Competencies," [Online]. Available: http://hdl.handle.net/10106/27634. [Accessed 3 4 2019].