

# Flipping the Makerspace to Maximize Active Learning Time in Introductory Workshops

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## INTRODUCTION

A flipped, active learning teaching method not only makes efficient use of limited makerspace time and space but also allows participants to work through instructional materials at their own pace before and during the workshop [1]. This is done by devoting face-to-face workshop time to hands-on activities, moving most of the instruction into online modules to be completed before the session starts. This contrasts with a common makerspace pedagogy of peer-to-peer instruction or assistance, which “takes advantage of the student-run aspect by creating a comfortable environment taught by peers” [2]. While in many instances the individual peer-to-peer instruction is the preferred way to meet the needs of makerspace users, in the case of students without previous makerspace experience, workshops that don’t require a routine commitment can be a great introduction without the perception of any obligation beyond the workshop [3].

In order to better understand student perceptions of the flipped makerspace workshop format, we conducted follow up surveys after every introductory workshop in order to answer the following research questions:

- RQ1: What are student satisfaction levels for introductory makerspace workshops taught using a flipped, active learning teaching method?
- RQ2: Do students value being able to work at their own pace in flipped active learning workshops?
- RQ3: Would students prefer peer tutoring over a flipped workshop to be introduced to a new technology?

## CONTEXT

The University of Victoria Libraries makerspace opened in April of 2017 and is a “Community + Machine Space” [4]. It is open to the whole university community including students, faculty, and staff, and its mission is to be a “makerspace and collaborative learning environment where people come together to share tools, and learn new skills” [5]. The physical space is 250 square meters (~2700 square feet) and the main collaborative space is flexible with tools and equipment on carts brought out during staffed hours 9am-5pm. The space can be used outside of the staffed hours with or without makerspace tools borrowed from the library’s Music & Media circulation desk.

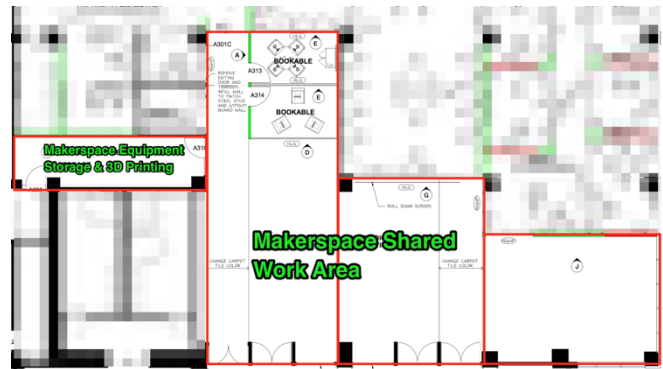


Fig. 1: University of Victoria Libraries DSC Makerspace

3D printers are available for use by the campus community, along with tools and equipment such as calipers, multimeters, Arduino kits, Raspberry Pi kits, DSLR cameras, Green screens, 360 video cameras, etc. In addition, twenty MacBook Pro’s with Adobe Suite along with other maker friendly software are available for loan during library hours. The makerspace also has ten 27” monitors that students can use with laptops in a dual monitor setup. One engineering student appropriately called the space a “makerspace lite,” because of a lack of heavier equipment like CNC, lathes, and band saws that are commonly found in makerspaces run by engineering faculties.

The makerspace currently has one full-time staff member and two part-time assistants. In the Fall and Spring semesters, one of five graduate student assistants are available each weekday for consultations during staffed business hours. The graduate assistants each have expertise in one of a range of areas including: mechanical engineering; software engineering; fine arts; statistics; and digital humanities.

While workshops are being added on a regular basis, and eventually more advanced instruction will be offered, the current flipped workshops offered were created because of the skills and interest of the staff who were first hired to set up the makerspace. As of August 2017, the following workshops were offered:

- Introduction to 3D Design with TinkerCad (60 min)
- Introduction to 3D Printing (60 min)
- Introduction to Electronics with Arduino (90 min)
- Introduction to Interactive, Nonlinear Stories with Twine (60 min)
- Introduction to Audio Recording & Editing with GarageBand (60 min)

- Introduction to Data Visualization & Mapping (90 min)

These makerspace workshops are not offered for university credit and are typically taken by students, faculty, and staff on a one-off basis because of their interest in a workshop topic. The makerspace has also partnered with a number of faculty members from across campus to offer workshops for specific classes, typically after the professors themselves have taken a workshop. For example, two Education professors leading a capstone course partnered with the makerspace to offer a combined 3D design and 3D print workshop (120 min) for their students. They wanted to introduce their students to skills that could be useful in helping them complete their capstone project, as well as in their careers as teachers.

The success of these workshops is measured in three ways: 1. quantitative and qualitative survey feedback, 2. the number of participants who return to the makerspace after the workshop, and 3. informal feedback from professors about how the workshop helped to enrich their course.



Fig. 2: Main makerspace workspace

### THEORETICAL FRAMEWORK

Learning theories can be useful when exploring a teaching method and their effectiveness, and in this case Cognitive Load Theory (CLT) helps describe why a flipped, active learning makerspace workshop pedagogy can be effective. Short-term working memory is like a computer buffer. If it is not able to process the information inputs into long term storage before it is full then it overflows and information is lost. In the case of a brain, after possibly no more than two or three items, short term memory becomes overwhelmed and learning suffers [6].

Pre-training in the form of pre-class videos and activities is one strategy to reduce the in-class cognitive load on learners to manageable levels by moving instruction out of face-to-face workshop time and allowing student to move through the videos at their own pace and watch them multiple times if necessary. Pre-training also helps differentiate instruction for students at different levels of knowledge and skill and helps students arrive at the workshop closer to the same level. Students can spend as much or as little time as necessary to fully prepare for a workshop so that there is no need for the whole class to endure a “forced march” lecture through the workshop instruction at the pace of the slowest learner in the group [7].

### METHODS

The literature review conducted for this paper surveyed the current research on flipped learning pedagogies for makerspaces. Unfortunately, there is currently a dearth of articles that specifically address flipped makerspace instruction, including academic makerspaces. In order to facilitate future research the author has posted a document with a list of search terms the author used, along with another document containing citation information for articles identified in the search beyond those included here [8].

A bespoke post-workshop survey instrument was utilized to collect quantitative and qualitative data from students following their completion of an introductory makerspace workshop [9]. The quantitative data from the surveys provided demographic information, while Likert scales were used on several questions to help gauge student satisfaction with the flipped, active learning teaching method used in University of Victoria Library makerspace workshops. Qualitative survey questions, along with informal conversations with participants were used to gain unstructured insight into both positive and negative perceptions about the flipped workshops.

### RESULTS

A total of 43 participants responded to a revised survey (n=43) with added questions for this paper, out of a population of 148 workshop participants for a participation rate of 29%, providing a margin of error of 11%. This end of summer sample, with updated questions for this paper, meant that many more faculty and staff participated in workshops than students. As a result, only 30% of the sample were students, and approximately half of those were graduate students. Also of note is that 55% of all introductory makerspace workshop participants are women and 45% are male.

*RQ1: What are student satisfaction levels for introductory makerspace workshops taught using a flipped, active learning teaching method?* Students strongly preferred face-to-face workshop time primarily devoted to hands-on, active learning activities, and pre-class time for online instruction. A total of 69% of students preferred or strongly preferred the flipped workshop, with a margin of error of 21%. No students reported any negative feelings towards the flipped workshop pedagogy, and 30% of students were neutral in their preference.

I prefer mainly hands-on activities during the workshop, and most instruction online before the workshop

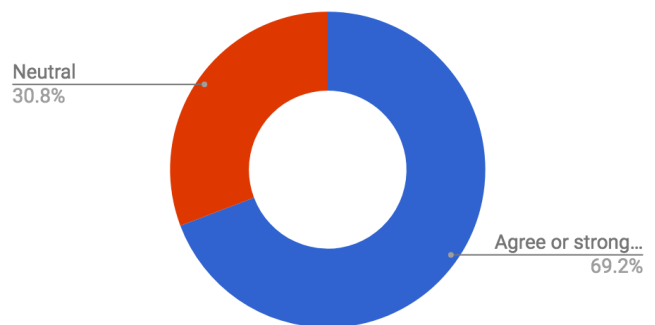


Fig. 3: Student preference for hands-on workshops & pre-class instruction

One student commented favorably about the flipped instruction saying that, “the pre-course work was valuable - the [instructional] YouTube videos and getting the software installed before the class.” Another student highlighted the value of the increased amount of hands-on time that flipped instruction facilitates by saying, “having instructors there to answer little questions as they come up as you’re working through a project is very helpful.”

When asked about workshop length, 60% of student participants were generally satisfied with face-to-face introductory workshops of 60 minutes in length, however approximately 8% preferred a 90-minute workshop and the remaining 31% preferred two or more 60 minute workshops.

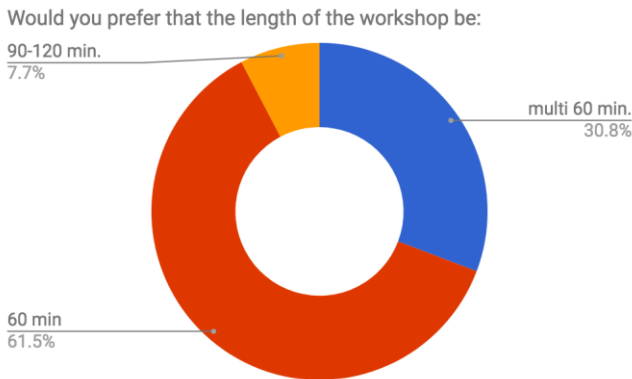


Fig. 4: Students preference for working workshop length

Because all the data for this paper was collected during summer months, a large percentage of participants were faculty and staff. It is interesting to note that the responses of students and non-library staff are quite similar in (see figure 5). On the other hand, 60% of faculty and library staff seem to prefer a more lecture style workshop.

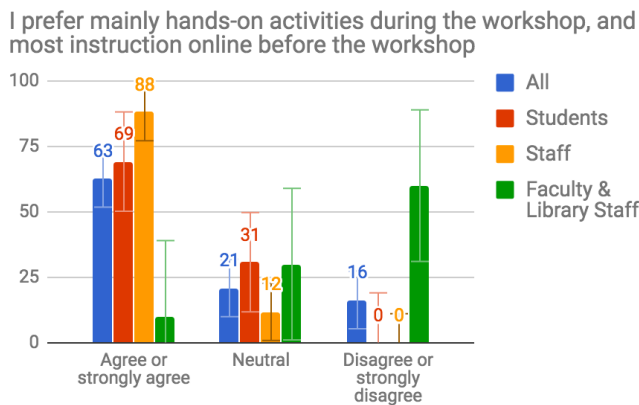


Fig. 5: Participant preference for hands-on workshops

RQ2: Do students value being able to work at their own pace in flipped active learning workshops? All students responding to the survey either agreed or strongly agreed that being able to work through the pre-workshop instruction at their own pace was helpful. The desirability of working at their own pace was also mentioned by some as an advantage of flipped workshops compared to other workshops where much of the instruction takes place during face-to-face workshop time. For example, one student commented, “I liked the tutorial sheets that walked you through simple projects, and it was

nice working along at your own pace and having the instructor there if you had questions.”

Being able to work at my own pace during the workshop was helpful

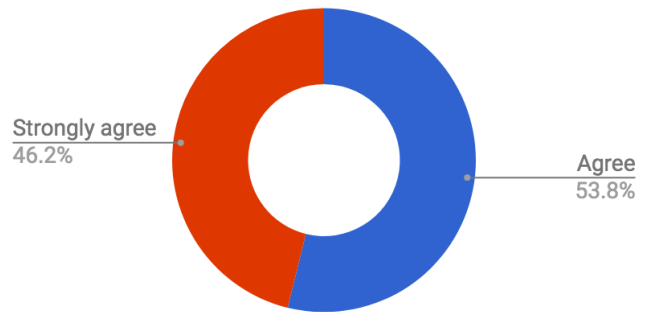


Fig. 6: Students preference for working at their own pace during workshop

In the survey comments a few participants expressed strong preferences for more time to work through the offered projects, and others requested that more advanced projects be provided. As a consequence, the makerspace may extend the length of some workshops, while making it clear that participants can leave earlier if they are done, and at the same time create additional more advanced projects for students to choose from.

RQ3: Would students prefer peer tutoring over a flipped workshop to be introduced to a new technology? When asked if they would prefer the workshop format over peer tutoring, 90% of responding students signaled a preference for the workshop over a peer-to-peer format. While no student stated why they prefer workshops, the fact that they attended an introductory workshop may indicate that they were interested in the topic/technology but were unsure where to start or what questions to ask. Sample bias might also be a factor considering that students who prefer peer-to-peer mentoring may be less likely to take a workshop.

I prefer the workshop format as an introduction to this technology rather than peer tutoring

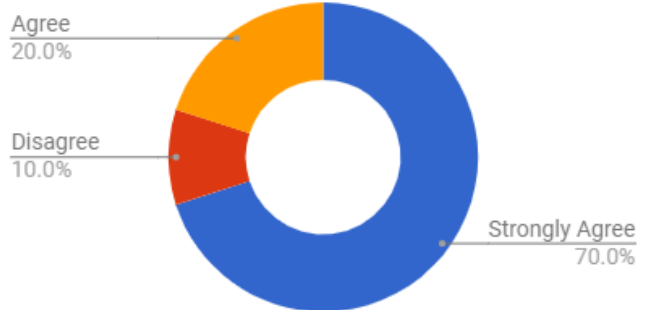


Fig. 7: Students preference for workshop format, or peer-to-peer tutoring

## DISCUSSION & CONCLUSIONS

The overriding goals in the creation of introductory makerspace workshops was to try to make face-to-face time as active as possible, while giving students the ability to choose what hands-on exercises they would like to practice their new skills on. Based on the generally positive survey responses, it appears that those goals have been largely achieved for students and staff. More than one participant mentioned, at the

end of a workshop, that being able to work through the pre-workshop instructional materials at their own pace was helpful because they did not have to worry about the learning needs of others in the class. Another participant commented that, “the combination of hands-on practice and instructor support was great!”



*Fig. 7: 3D Print workshop*

Some non-engineering students appreciated the flipped format when they took a workshop without a specific project in mind but wanted to learn how to use a makerspace tool and gain insight into what they might be able to use it for in the future [3]. As one first year student who took a 3D Design workshop put it, “I greatly appreciated the pre-class information package. It allowed me up to get up to speed on what to expect. I also appreciated the optional in-class projects that were provided. I had a lot of fun, too!”

Flipped workshops can also help reduce the amount of lecture time in the makerspace by moving most of the instruction into pre-workshop online modules. In the experience of the University of Victoria Libraries makerspace, a 90-minute workshop can typically become a 60-minute workshop by moving to a “flipped” pedagogy or teaching method. This is particularly important for makerspaces with mandates to market themselves broadly across campus and use workshops as a mean to achieve that goal. Another example of this is at the Georgia Tech Invention Studio where “in times of high machine traffic, students may seek supplemental information from the training videos. This ‘flipped classroom’ technique allows for training time in the studio to be focused on the details of practical machine use” [2].

While this study points to the promising nature of using a flipped, active learning teaching method, larger sample sizes are required to effectively explore the difference in perceptions between students from different faculties on campus, especially engineering.

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