

STUDENT PHOTO REMOVED FOR PRIVACY PURPOSES

UNC BeAM Laser Cutters: Four Check System Analysis

Project Team

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Executive Summary

Existing System Appraisal

Our project sought to analyze and propose solutions for the 'Four Check System' that facilitates the user queuing process for the laser cutters at the BeAM makerspace, located in Murray Hall at UNC. In short, the existing system has students sign in upon arrival, after which they must complete a series of four 'checks' before a student worker can place their name on the queue for the laser cutter. This system suffers from a number of pitfalls that increase the stress levels of student workers, frustrate users, and lead to inflated wait times. The problems include a lack of clarity and uniformity in communicating existing policies to users, unnecessary steps in the check system, overly rigid worker insistence on efficient materials use, and a lack of distinct accommodations for both experienced users and inexperienced users. We set out to find solutions to these problems that would:

- Increase worker/user satisfaction with system from ~40% to ~70%
- Decrease average user in-space wait time from ~90 minutes to ~45 minutes

Investigation and Design Methodology

We performed our analysis using a version of Beyer and Holtzblatt's *Contextual Design*, which proposes a design process founded on ethnographic user interviews and collaborative interpretation. Our first step was to identify the system's 'users.' Because our system affects both users seeking to utilize BeAM resources AND the student workers who manage day-to-day operations, we decided to gather data from both of these groups. Our data collection involved field interviews with users as well as consultations with permanent staff and surveys for both student staff and student users. Also, we looked at data from the past six months to learn about the users and how long they were in the space. We took detailed notes during the process and worked as a team to interpret the data gathered from each session. These sessions allowed us to model the experiences of each individual user and to later consolidate our models to reflect aggregated trends, problems, assumptions, and practices. We collected our field notes into an Affinity Diagram that helped both identify themes and construct a narrative-style picture of the system. This picture allowed us to point out different manifestations of the problems plaguing the system.

We consulted with our clients (BeAM permanent staff) on two separate occasions to both walk them through the Affinity Diagram and to present our consolidated models of the system in question. These consultations helped us both refine our understanding of the problems and brainstorm solutions in collaboration with the clients. After these consultations, we formalized our proposed solutions and mapped out plans for implementation.

Recommendations

Our proposed solutions align with the four problem categories outlined above.

Policy Awareness and Communication: We propose the adoption of handouts and posters that will clearly outline BeAM laser cutter policies. The handouts will help users track their own progress and reduce their reliance on worker explanations to guide them through the process. Brief, cleanly designed posters placed in obvious locations around the space will promote universal awareness of policies. This affects both of our metrics by tangibly reducing demands on workers' attention, providing inexperienced users with documentation that stop them from feeling overwhelmed, eliminating the wait time required for policy- and specification-specific questions, and eliminating variation in explanations between different student workers.

Check System Consolidation: We propose the consolidation of the existing 4-check system into a more streamlined 3-check system and the incorporation of an informal 'fifth check.' This consolidates the third and fourth checks, which both take place on the same system and asks that students export their files upon completion. This solution eliminates confusion and redundancy and simplifies the existing system without sacrificing functionality. We believe that this step will tangibly reduce confusion for both workers and users, therefore increasing satisfaction. It will also increase the speed with which users can complete their checks, decreasing wait time.

Updated Scrap Policy and Training: We propose 1) the adoption of a more concrete policy regarding student worker encouragement of scrap materials for laser cutter designs as well as 2) the implementation of a training policy that will have users create their design files to fit the bed of the laser cutter rather than a specific piece of material. These solutions will have the dual benefit of allowing users more flexibility to use new materials when necessary and also to decrease the number of instances in which the use of new materials will be necessary. This will cut down on both wait times and user frustration by greatly reducing the frequency of materials-induced redesigns.

Self Checks for Experienced Users: We propose the adoption of a system in which users can skip the first check, the Illustrator design check, with enough flawless passes through the check. Users will track the number of times that users complete this check without having to make any changes. Once a certain threshold is reached, a given user will automatically receive the 1st check in future visits to the space. This will eliminate needless redundancy for experienced users and increase the amount of time student workers have available to assist less experienced users. This will reduce overall wait times and increase satisfaction for users of all levels.

Description of Current System

1. Problem Definition

1.1 Setting

BeAM (Be A Maker) is UNC's makerspace for students, staff, and faculty, BeAM has three main locations on campus, Murray Hall, Hanes Hall, and Carmichael Residence Hall. BeAM staff teach at least 35 orientations each week during the semester. Each BeAM location is open 7 days a week for a total of 58 hours each week at each location. This project will focus on Murray Hall which has two laser cutters and Hanes Hall which has one laser cutter. In Murray Hall the laser cutters are to the left of the door, when you walk into the space. In Hanes Hall, the laser cutter is in the room to the left when you walk in. See Appendix A for photos of space.

1.2 Problem Statement

BeAM has no cohesive way to schedule, prioritize, or monitor people who use the laser cutter for class, research, or recreational making. Right now, user need is managed on a first come, first serve model in addition to a 90 minute limit per use of the laser cutter per patron. This model now includes a set of four checks, which are often unclear, that users must go through to get onto the machine. The first is a check of the design, the next is a check on the material a user wants to use, the third check is making sure the user has the setting for the printer figured out for each individual RGB color a user has in their design, the fourth check is them at the laser cutter. This model is not the best for the user groups or space, sometimes students are waiting in the space for longer than 3 hours to use the laser cutter for 90 minutes. This model causes stress for students who need the laser cutter for a class project and are in a time crunch. This leads to low user satisfaction, so low in fact, that they have almost seen physical altercations a few occasions due to user stress. In addition, BeAM tries to work with professors to schedule their laser cutter projects around each other to help fix bottlenecks but that does little to actually stop the bottlenecks that occur, because most students come at the same peak hours of the day, for example 4-6PM on a Friday or 2-5PM on a Tuesday. Additionally, BeAM's 4-check system does not adapt well to the various user classes. New users need the structure and organization of the 4-check system while learning how to properly use the laser cutter whereas experienced users are frustrated with the unnecessary repeatedness of the procedures.

1.3 Needs and Requirements

Coming from a previously unsuccessful and extremely unorganized system, BeAM requires a system that strives to promote effective and safe usage of tools and materials. While this 4-check system provides more organization, there are steps that can be merged to make the process more seamless. Our project team sought to improve transparency between professors and staff as well as the system itself with the users. After realizing that contextualizing the issues surrounding professor's scheduling was out of scope, the team fully focused on improving the current system with regard to new and experienced users. One of our initial goals was to include a time estimate for projects so users in the queue could better plan their workday. Another initial goal was to provide priority to those who had more experience with the system, however, BeAM desires an equitable space so that idea was more difficult to pitch.

Regardless, BeAM desired a new and improved system that tackles the efficiency issues and frustrations that the project team found while still promoting a safe learning environment.

1.3 Stakeholders

During our project our definition of who was a stakeholder changed because like previously stated we thought professors were stakeholders but since refocusing our scope we realized that professors were not stakeholders within the system.

Stakeholder	Primary Responsibilities
BeAM Student Workers	To help run day to day operations of the laser cutter and other machines. They also needed to help student patrons understand the check system. Teach classes about the machinery in the space. Check students in and out of the space.
BeAM Student Leaders	To help run day to day operations of the laser cutter and other machines. They also needed to help student patrons understand the check system. Teach classes about the machinery in the space. Check students in and out of the space. Manage a team of students workers and help them know when new policies come down from the technical supervisors.
Technical Supervisors	Oversee day to day operations of BeAM. Focus on keeping good relations with different entities on campus. They are the problem solvers for big problems.
BeAM Program Coordinator	Coordinate with the student workers for training. Coordinate with professors for use of the space for their classes. Help with day to day operations as needed.
BeAM Director	Note: This role was unfilled most of the time we were working on this project.

1.4 Objectives

1. Create a system that will facilitate the use of the laser cutter for all users, in a way that does not hinder use for any user (researchers, classroom users, and casual student users). The system needs accommodate classroom and research use needs during busy times better than it does now.

2. Create a way for student staff to oversee the 90 minute time allotments of time at the laser cutter without hindering their responsibilities as a BeAM Employee.
3. Current user satisfaction and BeAM employee laser cutter satisfaction is ~40% the goal is to get to ~70%.
4. Current laser cutter wait time for users is ~1.5 hours the goal is to reduce it to ~45 minute wait time. This refers to wait time in the physical space of BeAM.

2. Investigation

2.1 Data Gathering

Parsed through the quantitative data that BeAM already has

- Reason for Visit (Class, Research, Personal)
 - The ratio of this kind of user.
- Time In and Out
- Peak Laser Cutter Hours

Quantitative Data we collected

- User Satisfaction Survey
- Employee Satisfaction Survey

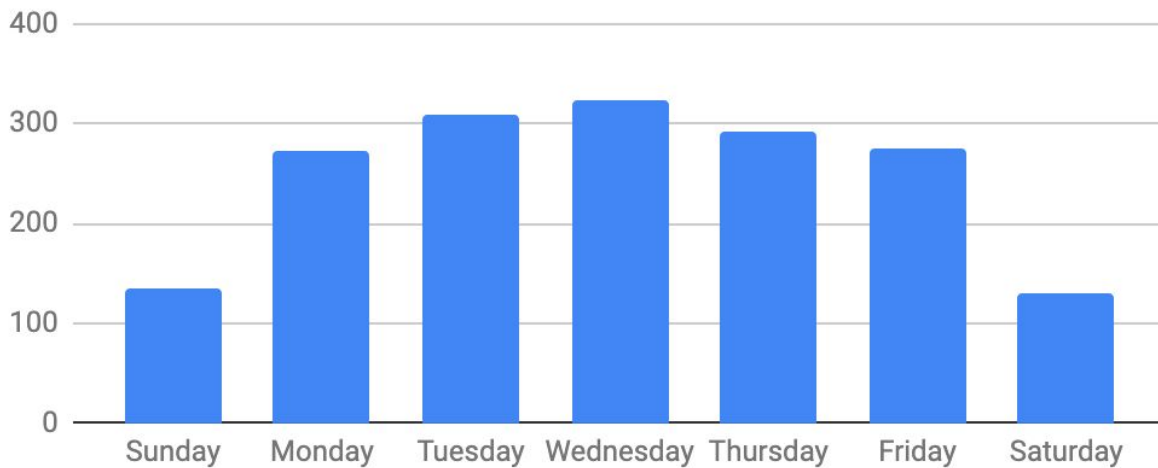
Qualitative Data we collected

- Interviews BeAM Full Time Staff (Anna) (Drew)
- 'Contextual inquiries with
 - BeAM Student Staff
 - BeAM Student Users
 - Professor expecting students to use the laser cutter
 - How easy is it to get time on the machine
 - How much time will students spend there
 - Expectations for students using machine.

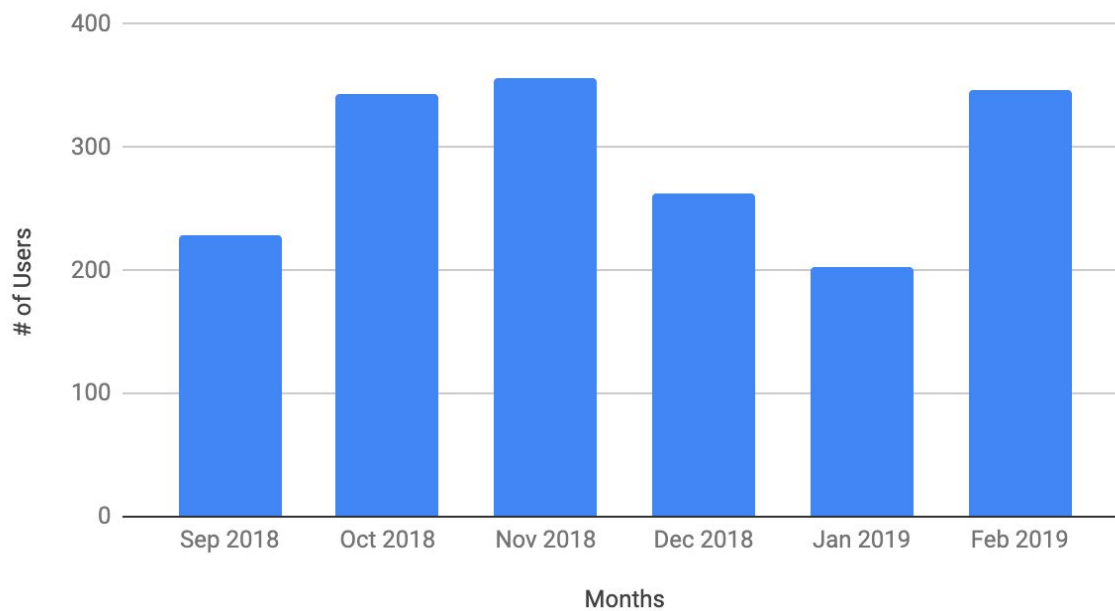
2.2 Quantitative Data Analysis

The following graphs show our findings from our analysis from the user data collected by BeAM in the 6-months before we started this project.

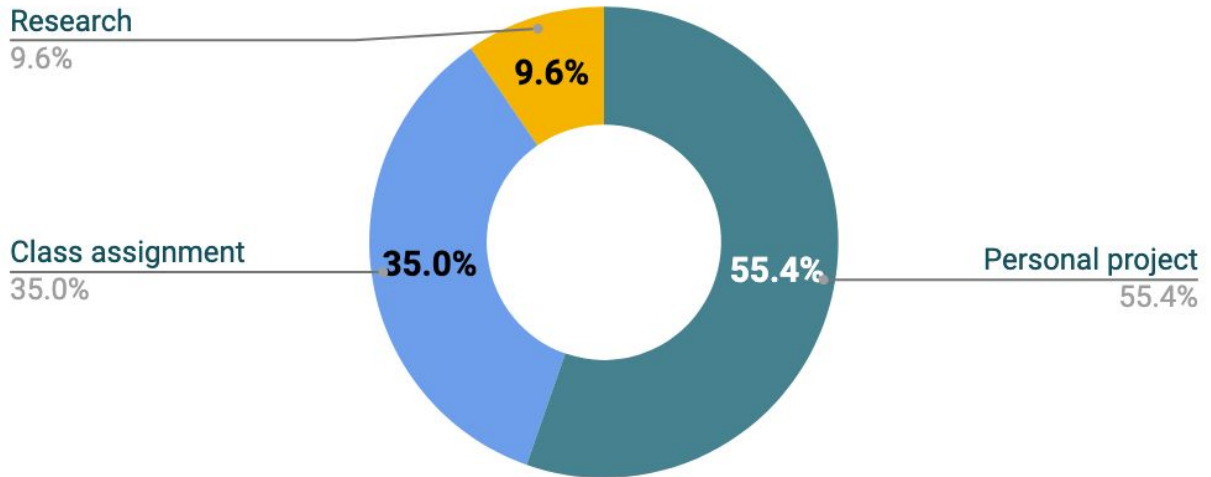
Laser Cutter Usage by Day-of-the-Week



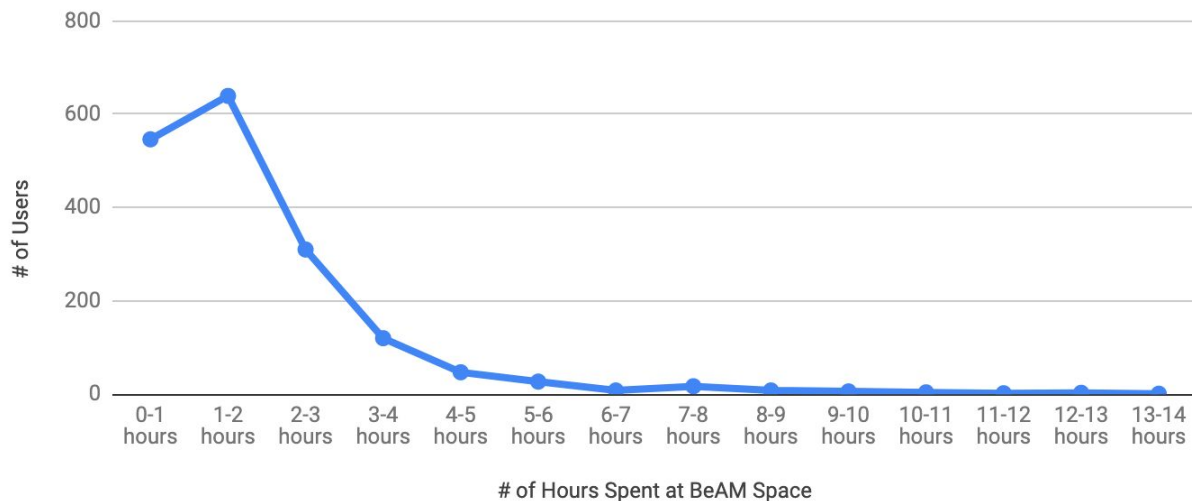
Monthly Usage of BeAM Space



Project Purpose using Laser Cutter



Hours Spent at BeAM for Laser Cutter



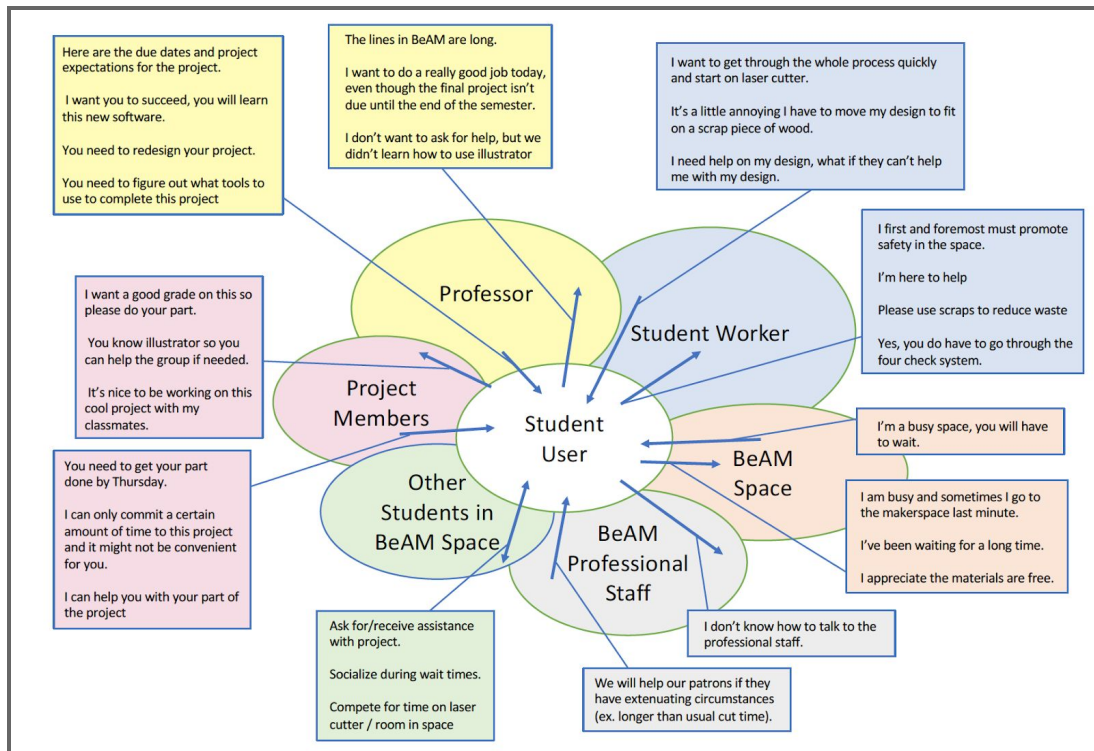
Key Takeaways

1. From this data we saw that our original estimate of waiting time in the space was pretty spot on, the majority students are spending on average about 1.5 hours in the space. There are a lot of students who are spending even more time in the space and that could be improved.
2. The middle of the week is the busiest time for the laser cutter.
3. The majority of patrons are using the space for personal projects.

2.3 Data Interpretation, Consolidation, and Breakdowns

We developed several models to understand what was happening in the space. Here are our models and findings.

2.3.1 Cultural Model Student User

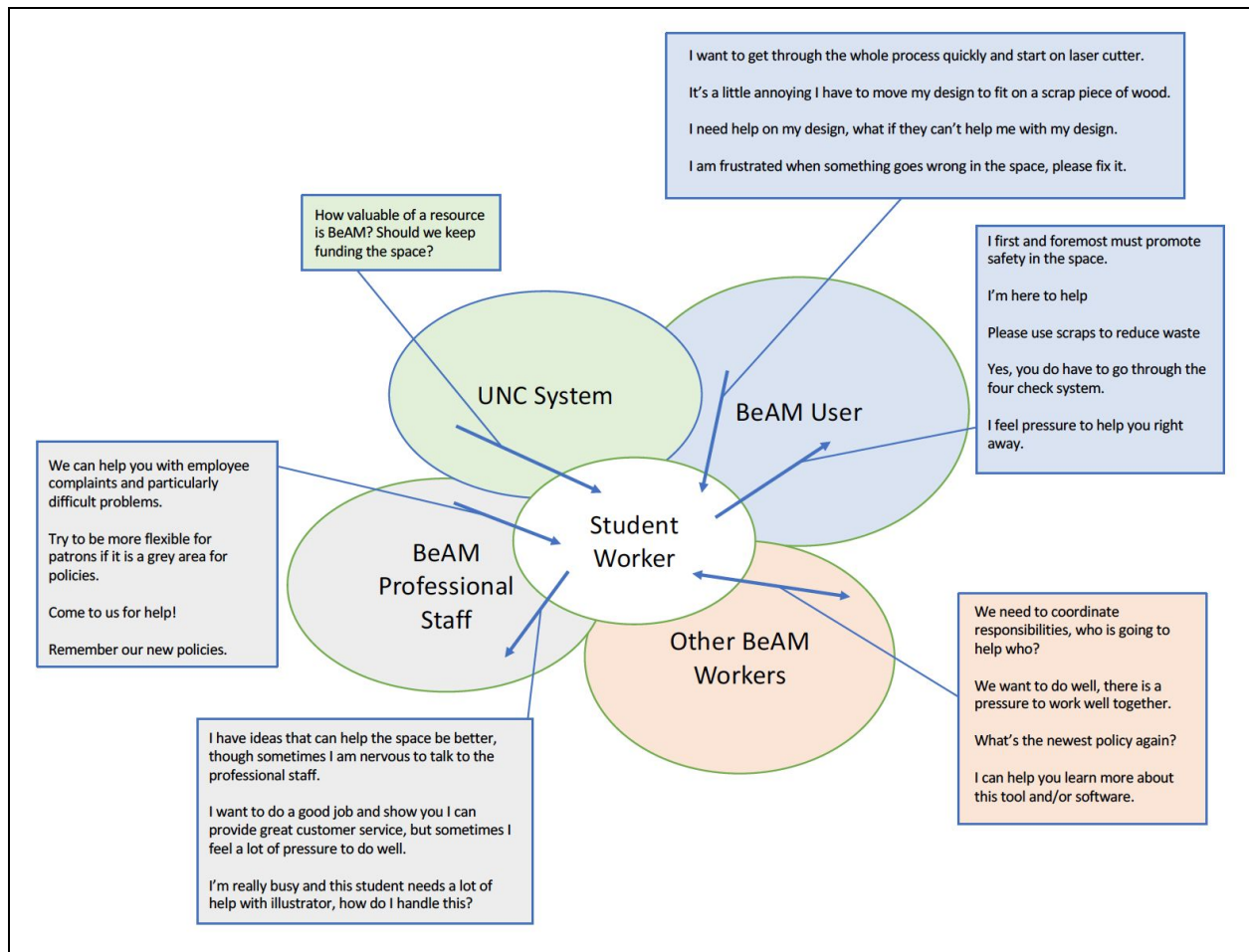


Key Takeaways:

1. The student user has stress while going through the 4-check process and being on the laser cutter.
2. A major issue that can be seen is an expectation of high output in a limited resource environment.
3. The BeAM space is often over capacity and students are pressured by outside influencers, like the professors and project members, to complete their work.
4. There appears to be a fear of professional staff even though they are more than willing to help.

Improving these interactions and reducing the stressors on the student will not only result in a more streamlined workflow but also an improved user satisfaction.

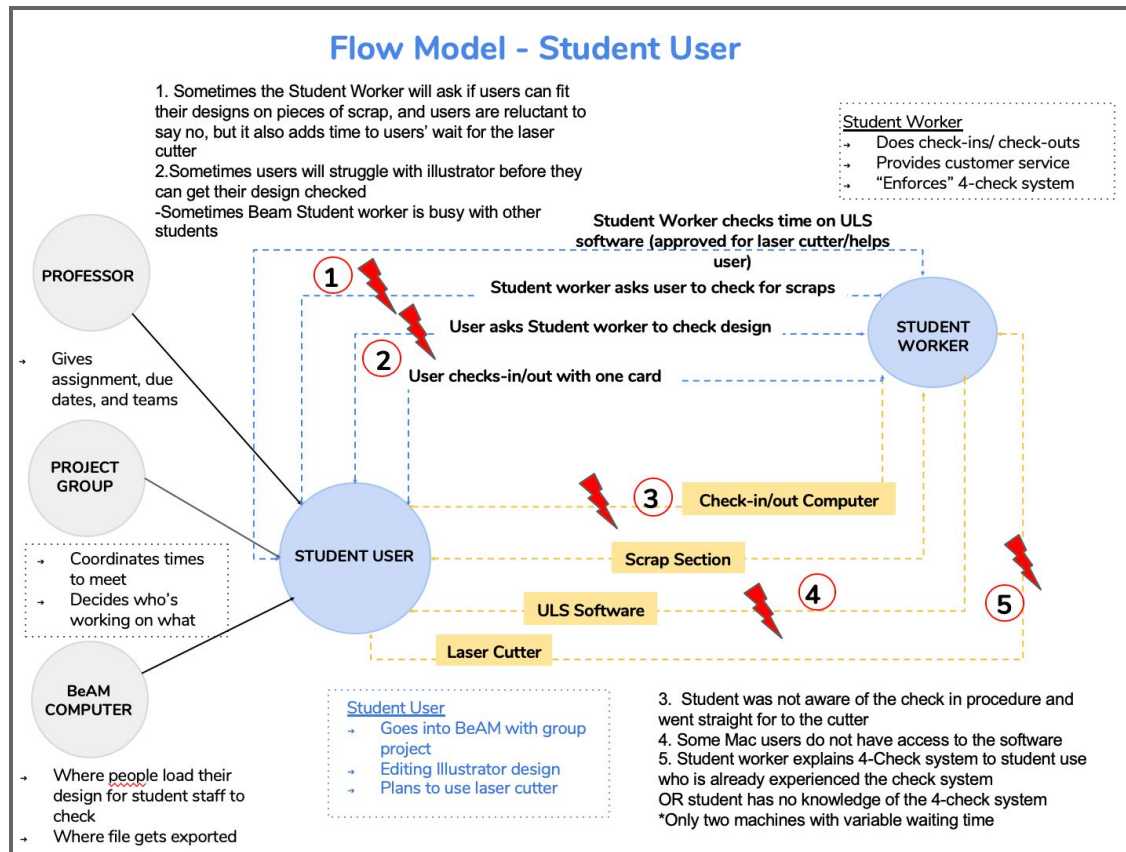
2.3.2 Cultural Model Student Worker



Key Takeaways:

1. The student worker has stress while taking a patron through the 4-check process.
2. There is a breakdown between the professional staff and student workers when it comes to giving the professional staff suggestions on improvements for the space.
3. The student workers see each other as a source of information on policies within the space. As one student put it, this leads to policies being distorted through a telephone process.
4. The student workers are not immune to worrying about the loss of funding in the space from the UNC System.

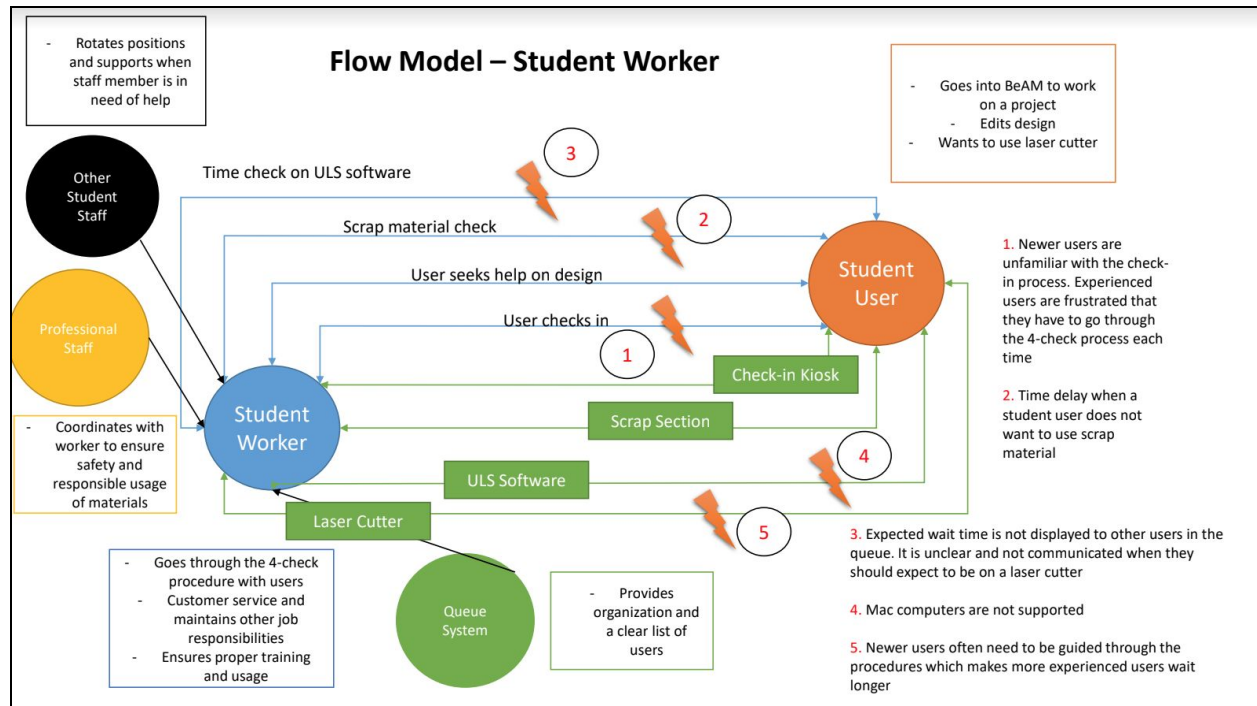
2.3.3 Flow Model Student User



Key Takeaways:

1. Many users are misinformed about the 4-check process, sometimes enforced with only 3 checks rather than 4.
2. Students are simply unaware of the 4-check process.
3. Illustrator file errors that newer users experience and poor workflow efficiency.
4. There are discrepancies in how individual staff members used or rather did not use the system as intended.

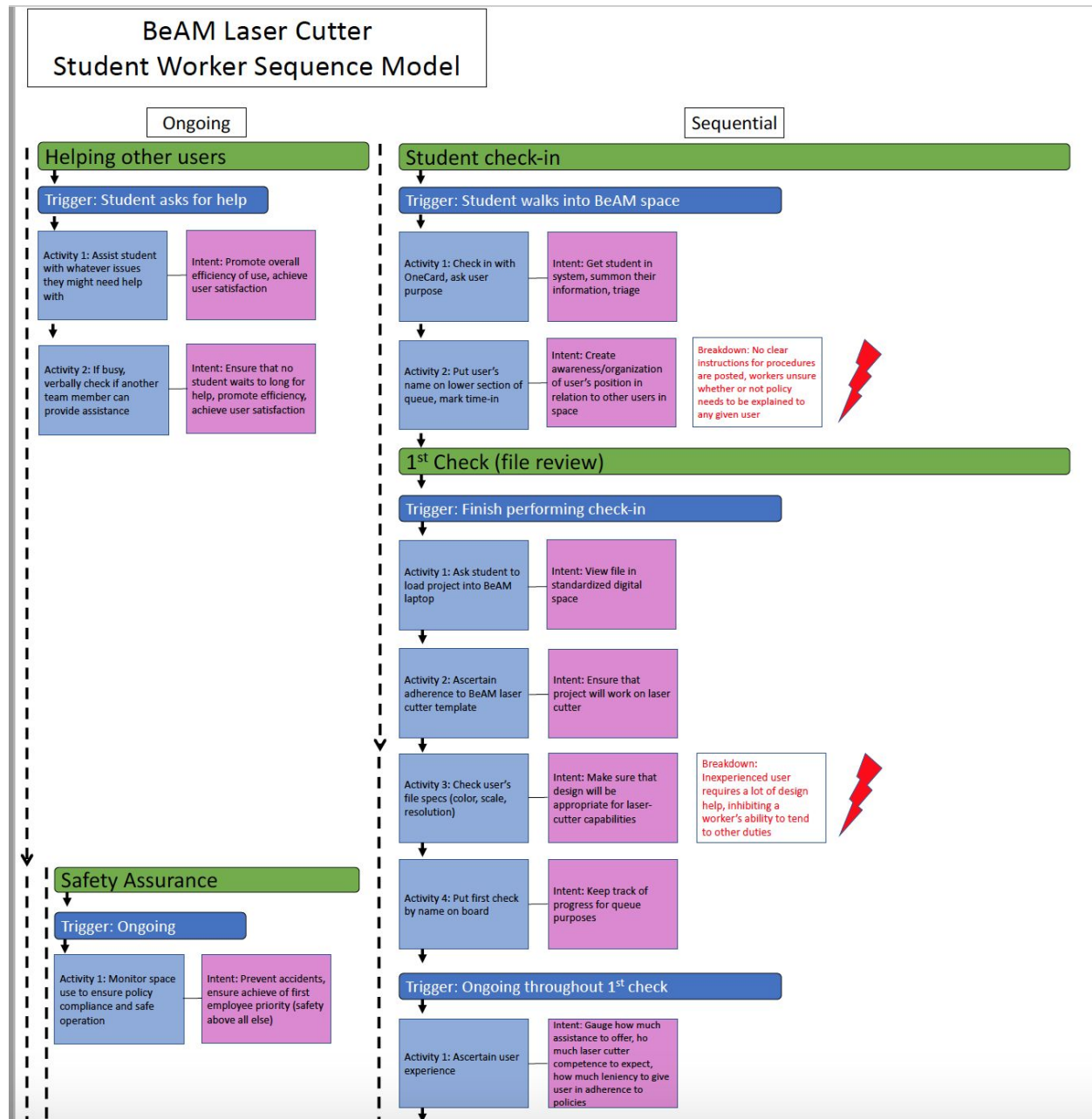
2.3.4 Flow Model Student Worker

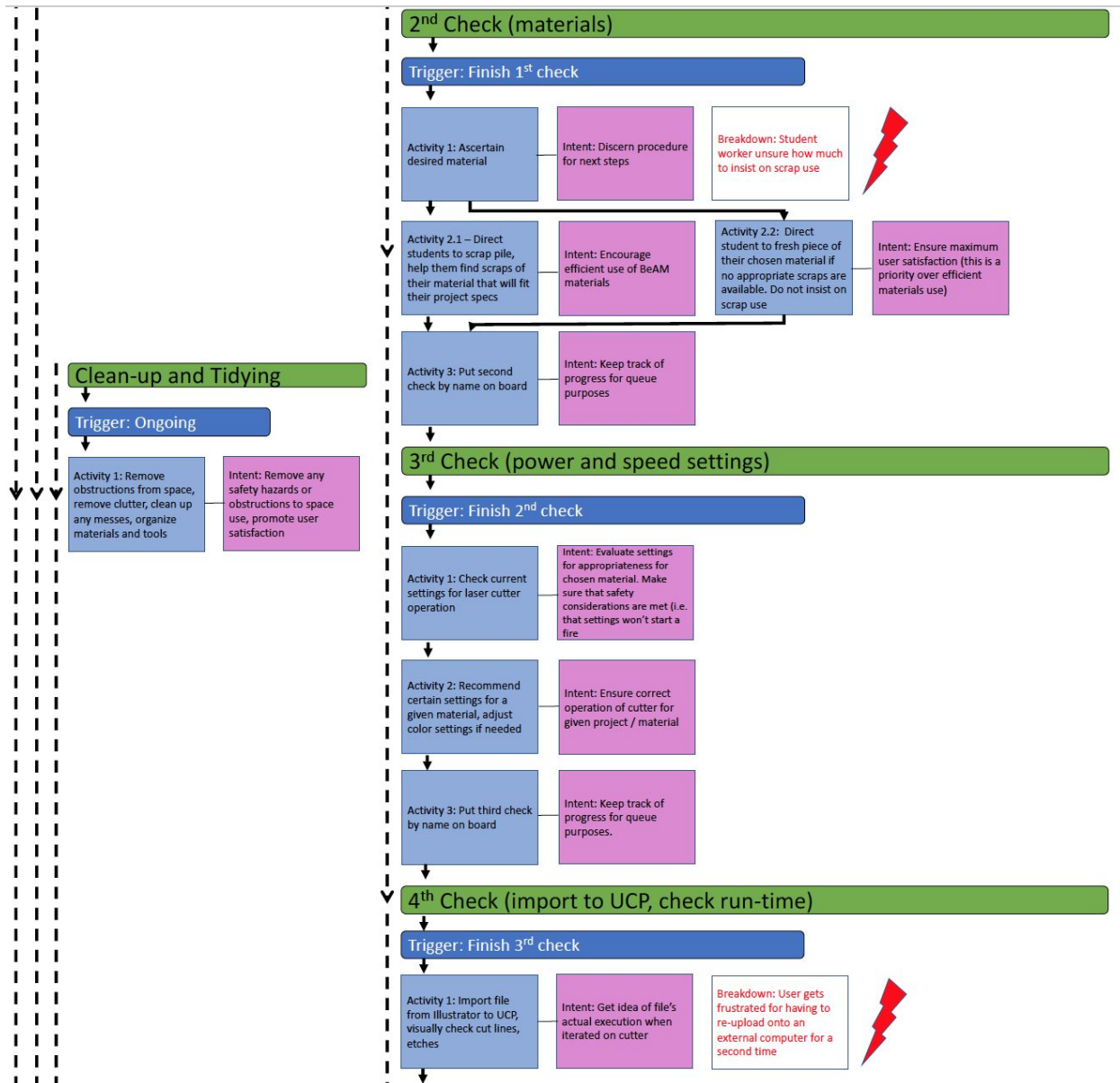


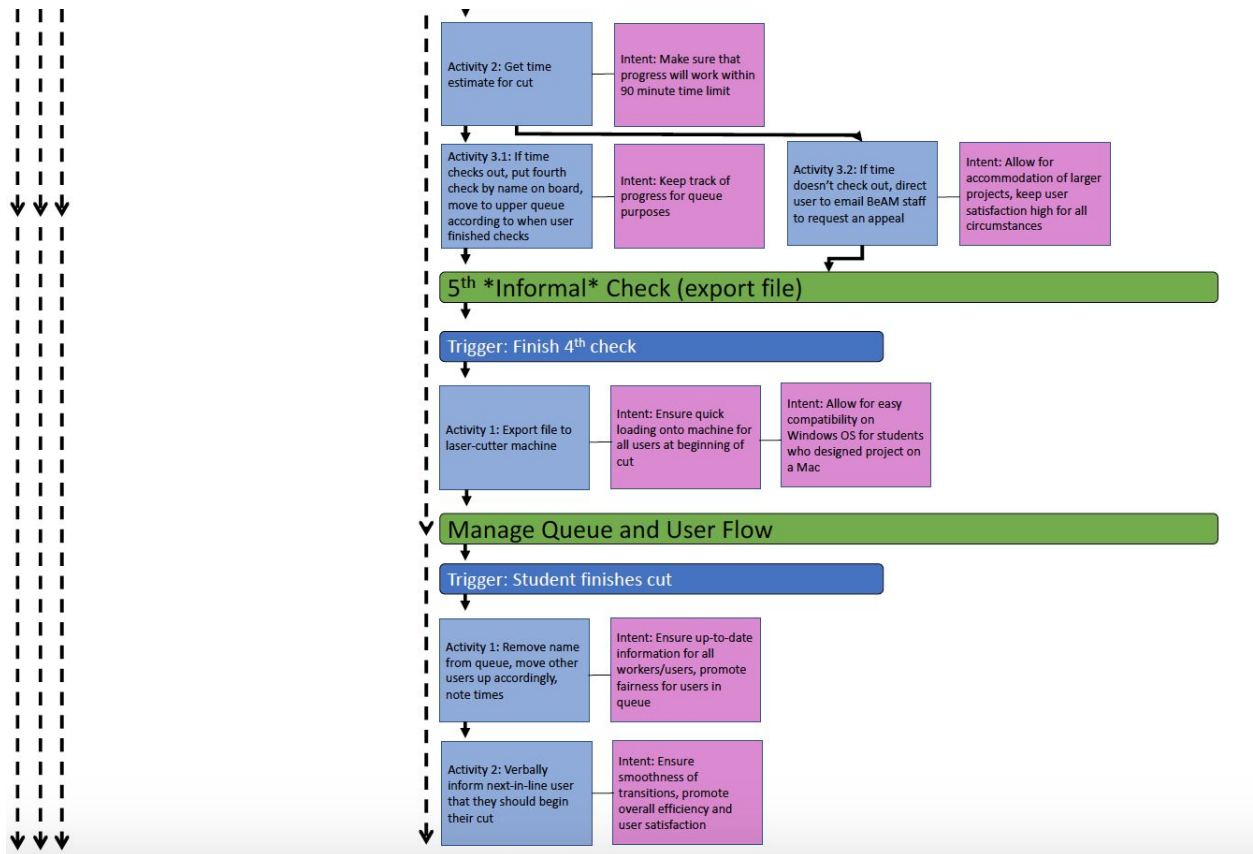
Key Takeaways:

1. Some newer users are unfamiliar with the check-system. This leads to frustration.
2. Students patrons have a time delay within the system if the student worker makes them redesign their whole file to fit scrap.
3. Expected wait time questions from patrons takes up the workers time.
4. Mac computers are not compatible with the printing software.
5. Newer users needed to be walked through the system and this takes up a lot of the workers time.

2.3.6 Student Worker Sequence Model



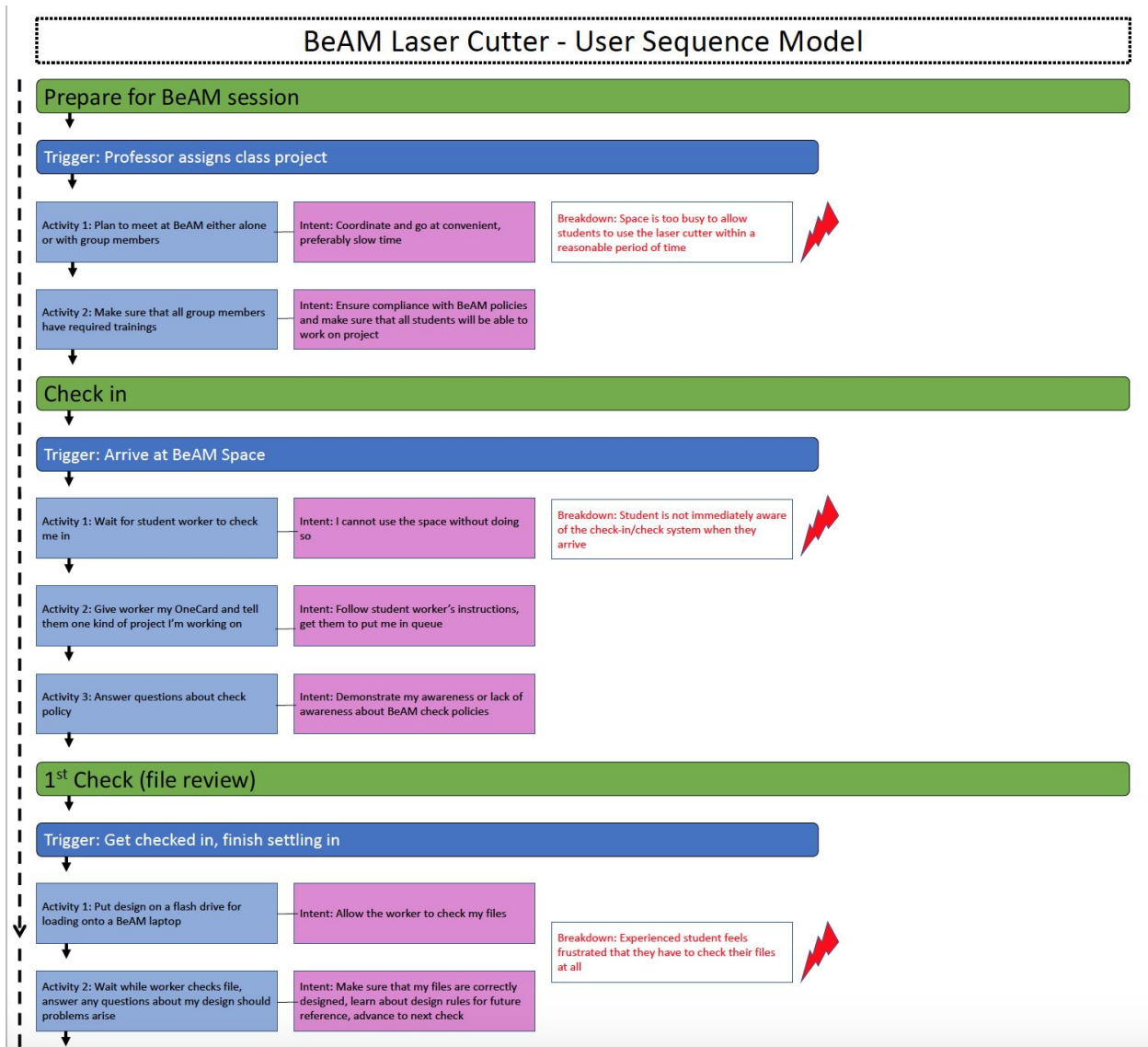


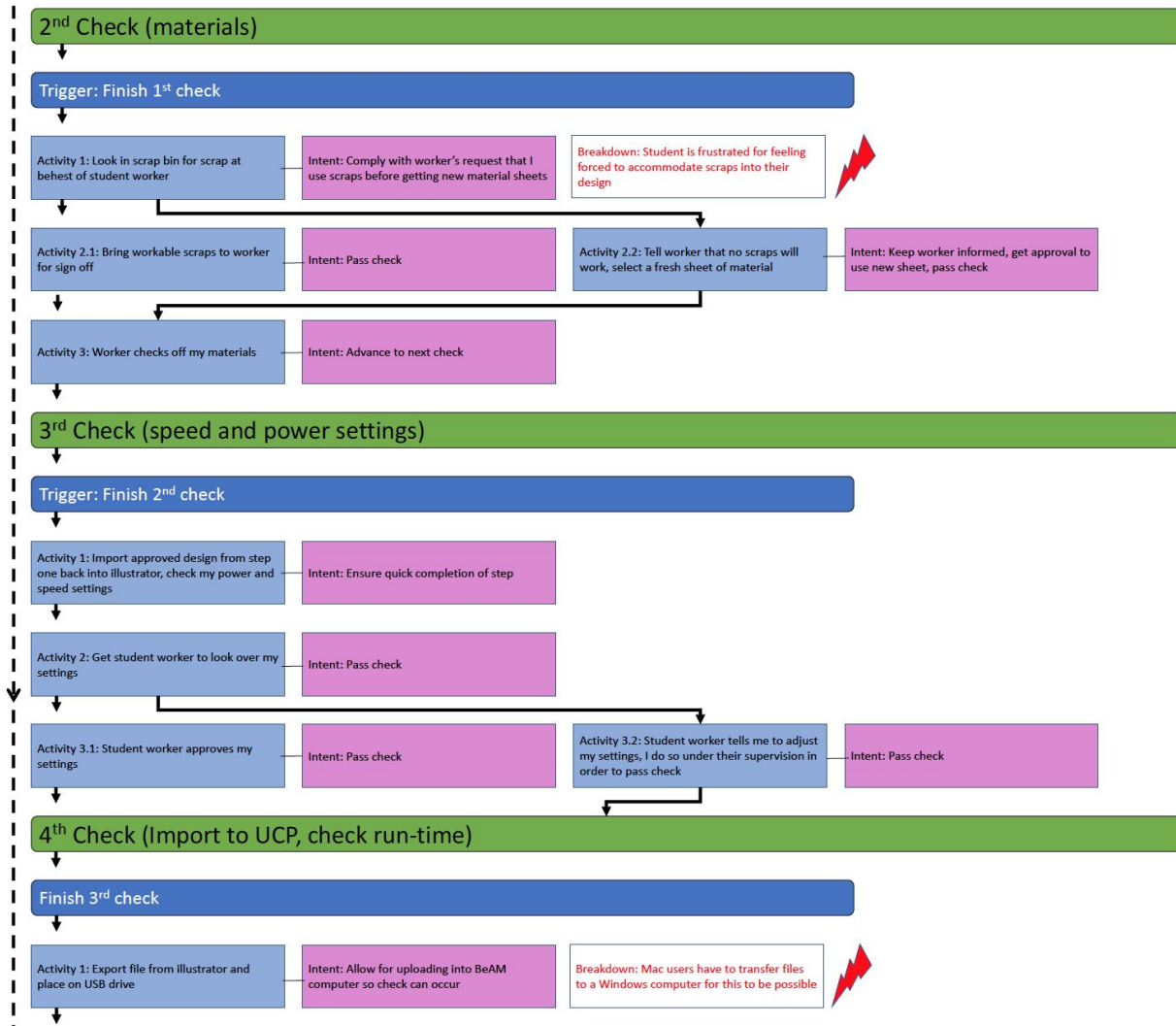


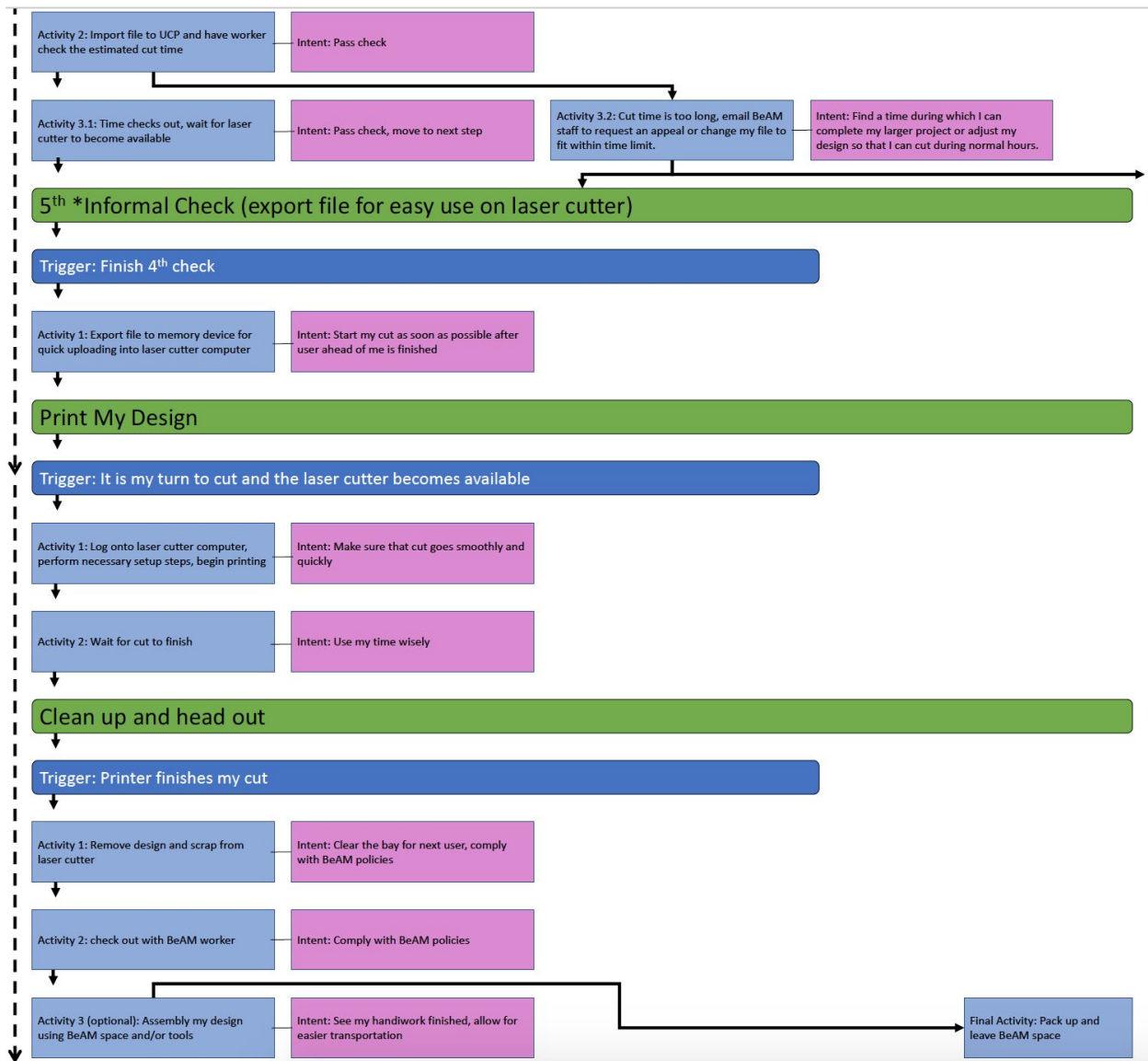
Key Takeaways:

1. There are no clear instructions for procedures are posted, workers unsure whether or not policy needs to be explained to any given user.
2. Inexperienced users require a lot of design help, inhibiting a worker's ability to tend to other duties.
3. Student workers unsure how much to insist on scrap use, which leads to dissatisfied user.
4. Users get frustrated for having to re-upload onto an external computer for a second time.

2.3.7 Student User Sequence Model







Key Takeaways:

1. Space is too busy to allow students to use the laser cutter within a reasonable period of time
2. Students are not immediately aware of the check-in/check system when they arrive
3. Experienced students feel frustrated that they have to check their files at all
4. Students are frustrated for feeling forced to accommodate scraps into their design
5. Mac users have to transfer files to a Windows computer for this to be possible

2.3.8 Personas



Camden

Female, 19

"I love working at BeAM, its the best job on campus! Sometimes there are challenges helping new users understand the tools in the space, but I do love a challenge!"

MOTIVATIONS

Working at BeAM allows Camden to learn maker technologies, something she is interested in making more sustainable. She likes working there because the community is kind and creative.

DEMOGRAPHICS

Major: Environmental Sciences

Year In School: Sophomore

Club Memberships: Carolina Green Team, UNC-CH Scuba Club

LIKES

- Hanging out at BeAM on her off hours
- Students at BeAM working on sustainability projects
- Her pet gecko, Alfred
- Thai Food

DISLIKES

- People who are rude to BeAM employees
- People who think they know everything already and don't heed her expertise
- Pickles

GOALS

- Make sure users and staff are being safe and responsible in the space.
- Quickly and efficiently help users understand maker tech.
- Help BeAM be more sustainable.

CHALLENGES

- Users who get frustrated about the 4-check laser cutter system or wait time.
- Knowing when to bring up suggestions for the space to professional staff.

MAKER EXPERIENCE

Camden feels comfortable helping users with the Laser Cutter, 3D Printers, and Vinyl Cutter. She is developing her skills in the wood shop and with sewing, serging, and embroidering. She is excited for BeAM to open it's metal studio because she did metalwork in high school.



Willa

Personal Project User

Female, 21

"I love coming to BeAM to make fun things! It can be helpful for my research in sports performance and I like to give my friends gifts made on my own!"

MOTIVATIONS

BeAM is essential for Willa for her research and studies, and while working on her projects, her value in friendship and creativity make BeAM even more fun to explore.

DEMOGRAPHICS

Major: Biomedical Engineering

Year In School: Senior

Club Memberships: UNC Beach Volleyball Club

LIKES

- Supporting UNC sport teams
- Hanging out with friends
- Doing outdoor activities
- Doing researaches in the area of health sciences and sports performance

DISLIKES

- Staying indoors for too long
- People who are not friendly and open-minded
- Repeated and boring things

GOALS

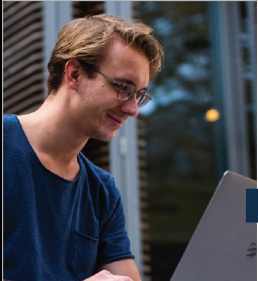
- Work on projects that are helpful for her research in sports performance.
- Design on her own and build it from scratch for gifts for friends.
- Develop more advanced design skills.

CHALLENGES

- Lack of Illustrator skills hinder her possibilities of more complex designs
- Busy with other research and study activities, so it is frustrating sometimes to wait for long.

MAKER EXPERIENCE

Willa is confident in using BeAM tools to work on her research and personal projects, other than the laser cutter, she also has some experience with 3D printer. Overall, she think the four-check system is useful to help the space get more organized.



Aiden

Male, 18

"It's so great that BeAM has free tools to use for my group project! Otherwise, we would have to go out and buy all the tools and supplies myself."

MOTIVATIONS

Using the space and tools that BeAM provides is great for Aiden, since freshman can't park on campus and he wouldn't be able to go off campus to get tools and supplies for his group project.

DEMOGRAPHICS

Major: Economics, Minor in Entrepreneurship

Year In School: Freshman

Club Memberships: Carolina THINK

LIKES

- Playing frisbee in his free time
- Chatting about new entrepreneurial ventures
- Building things with BeAM tools

DISLIKES

- Crowded areas
- People who can't follow the rules
- State Fairs

GOALS

- Meet with group to work on class project
- Finish Illustrator Design and get onto laser cutter that day

CHALLENGES

- Working with Illustrator to refine designs for the laser cutter
- Being unsure if there will be a line for the laser cutter that day
- Worrying about having to get back on the queue if the design didn't turn out correctly

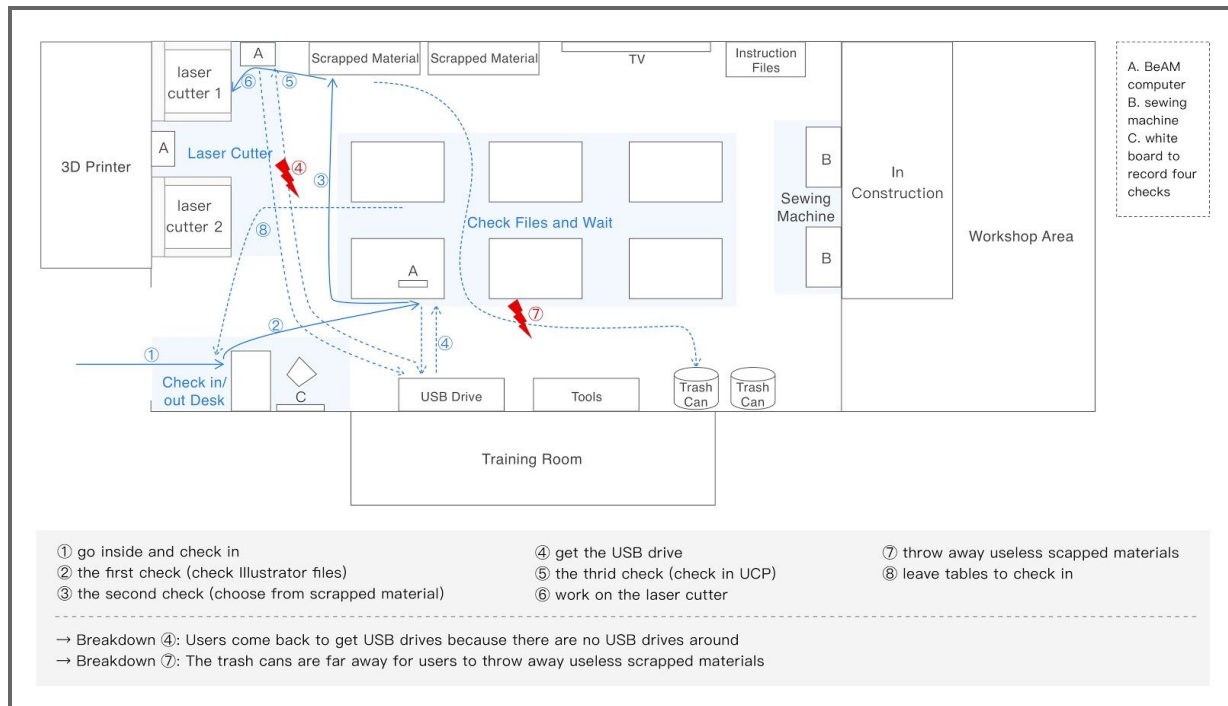
MAKER EXPERIENCE

Aiden has been to the BeAM space hundreds of times to work on class and person projects, and understands that the 4-check system is required to maintain flow of the space. He's glad that the space is located on campus since his semester long group project will require using the laser cutter many times.

Key Takeaways:

1. Some student workers are very passionate about the scrap system.
2. Experience Users are a little frustrated with the check system.
3. Most student users though are not super upset with the check system, sometimes they just upset about little things about it.

2.3.9 Physical Space Model



Key Takeaways:

1. A major breakdown but easily approachable issue was the placement of the trash cans. Simply moving the trash cans closer to the laser cutters would allow users to easily throw away their trash while not having to move throughout half of the space and potentially disrupt the flow of other users working there.
2. Our team also noted that the USB drives were not easily accessible and moving them may assist in easing the workflow of users, however, we were unaware that the staff placed them in that region for a particular reason.
3. Overall, the physical space at BeAM is relatively organized, simplistic to follow, and not as cluttered as other makerspaces. The main issue in the space is simply due to a lack of laser cutters to meet the growing demands.

2.4 Summary of Pain Points

2.4.1 Scrap

1. Gap
 - a. Workers insist too heavily on use of scrap materials for laser cutter projects
 - b. Some workers do so more than others
 - c. Trash Can Placement
1. Impact

- a. Many students must spend extra time and effort to accomodate scrap use into their design or redesign their project entirely
- b. Increased time for users to pass through system in some instances and increased user frustration

2.4.2 Experience Levels

- 1. Gap
 - a. Experienced and novice users have different needs that are not reflected in the one-size-fits-all check system
- 2. Impact
 - a. Experienced users feel frustrated for having to go through redundant steps designed for the novice user
 - b. Wait time is increased by imposing unnecessary requirements on experienced users

2.4.3 Awareness

- 1. Gap
 - a. Users are not aware of check system in general
 - b. Users lack clear guidelines for specific requirements within check system
- 2. Impact
 - a. Explanation and procedure walkthroughs require more worker attention than is necessary
 - b. Wait time is increased because of maxed out worker bandwidth and increased check duration for each user

Recommendation for New System

3. Decision Drivers

After conducting six contextual inquiries on student workers and student users respectively, we consolidated models each of us bulily and output these models:

- Cultural Models for student user and student worker
- Flow Models for student user and student worker
- Sequence Models for student user and student worker
- Personas of student worker, students user (class) and student user (personal)
- Physical Model

Based on analysis of these models and affinity diagram, we put forward the following suggestion for the current system.

4. Recommendations

4.1 Digital Queue System

Description of the idea

The digital queue system is triggered when the maker space is relatively free and send notifications to student users. For the first version, the online queue is not implemented, only the notification is available.

How we developed the idea

According to the reflections from contextual inquiry and surveys, as well as by referring to the breakdowns in flow models, an obvious problem is spotted that the average waiting time is long, sometimes it even takes 3 hours or more for students to have access to the laser cutter. One reason of this problems is the limited number of laser cutters, the other reason is the ambiguous waiting time. We proposed the suggestion to record the estimated time of the project according to the UCP software, however this can cause some other burdens for the system. Considering the current input including signing time, start time on the laser cutter and four checks, this requires extra work of student workers and there is not enough room on the whiteboard. Besides, the showing time on the software is not always accurate. Something unexpected can happen, for example, the material is not cut through thus it can cost more time. Meantime, while we are conscious of the busy time and idle time of the space from the contextual inquiry and survey, students are not aware of this information. The digital queueing system is what comes in mind under such circumstances.

Advantages and potential risks

This solution enables students to get notified even when they are not at the makerspace, so that the laser cutter is made most use of in spare time and users don't need to stay in the space to wait for a long time. Moreover, no extra work is brought to student workers since the system is triggered automatically. The first version only include function of notification, further improvement of the system could be making it possible for students to sign up for a spot in the online waiting queue, however, this may lead to conflict with the current first come first use queue on the spot, this problem remains to be balanced.

4.2 Self-check System

Description of the idea

This suggested solution can be divided into two parts, the first part is to distinguish between experienced users and new users. It is implemented by tracking how many flawless illustrator checks a user has completed with the use of punch cards. After they reach a threshold, we identify them as experienced users so that they can skip the first check. The second part is to print out self-check sheets, in this way, users can get familiar with what they need to present to student users to get through the four-check system. With the reference of the self-check sheet, users can spot and correct mistakes in design, there is no need for student workers to repeat the same requirements to different users.

How we developed the idea

From the breakdowns in cultural model and flow model, we concluded that experienced users and first-time users are confronted with different problems in the system. For experienced users, redundant check steps is a waste of time, however, first-time users have trouble identify and fix design issues. In order to solve the above problems, we came up with the solution of self-check sheet.

Advantages and potential risks

This can help solve the problem of common design issues, speed up the process of experienced users and save time for student workers. For example, during illustrator file check, the sheet can be used to specify correct color mode and etch details; for windows users, the sheet can serve as a reminder to make sure that they installed UCP in advance; users can also use the sheet to confirm laser cutter settings. On the other hand, this solution allows student workers to refer to documentation rather than walking students through every problem.

This solution has a potential risk that even though some users are experienced, being able to skip the first check can make it difficult to spotify problems if they occur in the later stage. Besides, new users may still prefer direct communication with student workers. Further improvement of this solution could be writing a script to check illustrator files for the design specification settings, this way student workers can concentrate on communication during solving problems.

4.3 Reinforcement of Policy of Scrapped Material

Description of the idea

This suggestion can be divided into two parts. The first part is to modify the training process and educate first-time users about the principle of designing for bed. The second part is to implement explicit customer-first service policy on student workers, in other words, student users are encouraged to use scrapped material but it is not a strict rule.

How we developed the idea

According to the affinity diagram from contextual inquiry, confusion about the policy of scrapped material reoccurs among first-time users. As a consequence, student workers are stuck between the principles of customer-first service and economical use of material. Besides, student users doesn't have enough knowledge about whether their design can fit into the scrapped material. For some of them, it is a burdensome task to look through all pieces to find a suitable one. Particularly, unnecessary hurdles may arise when a design could not fit into a piece of scrapped material and users need to processed the cut part for the second time. For above reasons, we came up with the suggestion to reinforce this policy

of scrapped material.

Advantages and potential risks

This suggestion aimed to solve this problem by explaining the policy of scrapped material in training classes, as well as balance the principles of customer-first service and economical use of material. For student workers, the reinforced scrapped material policy can save them the trouble of repeating the same regulations.

Potential risk of this solution is that since the scrapped material policy is not as strict before, this flexibility may lead to a waste of material.

4.4 Increase Awareness of the Check System

Description of the idea

This suggestion is to create an infographic poster that details procedures and policies for 4-check system and the queue system. The poster should be easy to read at the first glance so that users are immediately aware of the space's policies and how they work.

How we developed the idea

The lack of awareness among users is reflected in our flow models. Since the four-check system is relatively new, student users are not familiar with it. This may lead to a waste of time during the four-check process.

Advantages and potential risks

This solution can clearly delineate specifications and requirements, in combination with the self-check sheet, it may help eliminate need for student workers to repeat instructions over and over again. Further improvement of this solution could be to apply this promoting in advance solution to every new policy the makerspace releases. A potential risk to this solution would be taking up wall space that BeAM could be using for other things.

4.5 Modifications to Four-Check System

Description of the idea

We suggested to modify the four-check system to three-check system by combining power and speed setting with the time on the UCP software.

How we developed the idea

Our contextual inquiries indicate inconsistent implementation among student workers of the four-check system. Similar to the reason of unawareness among student users, student workers interpret this new policy differently and the implementation of the policy varies from person to person. According to the contextual inquiry, some student workers think four checks are redundant since the three and four step (checking speed and power settings and checking estimated time on UCP software) are checked together. However, other student workers think implement an informal check to export file for easy use on laser cutter. This gives us the inspiration of modifying the four-check system to three-check system.

Advantages and potential risks

This modification can speed up the time of checking process for student users and contributes to the

conformity of the check system among student workers.

Potential risk of this solution is that users who already adapted to the four-check system need to adjust themselves to this change in the checking system, however, adopting the suggestion of increasing awareness of the check system may make up this drawback.

Implementation Plan for New System

<u>Recommendation</u>	<u>Goal</u>	<u>Activites</u>	<u>Person(s) responsible</u>	<u>Risks</u>
Digital Queue System	To show users how long the queue is at any given moment. If users opt in it will push notifications to when the laser cutter queue doesn't have very people people in it.	Note BeAM is already working on this at the moment, so it is feasible and within their budget.	BeAM Professional Staff and their contractors.	This may lead to conflict with the current first come first use queue on the spot if everyone comes at the same time from the notification. This problem remains to be balanced.
Self Check System	Acknowledge experienced users in the BeAM by documenting how many times they have used the space so the can go through the check system without as much oversight from BeAM student workers than less experienced users	Punch cards for check passes. Potential for future digital queue functionality so people can check in and it says they are certified to do their own checks.	BeAM student workers and staff	This solution has a potential risk that even though some users are experienced, being able to skip the first check can make it difficult to spotify problems if they occur in the later stage. Besides, new users may still prefer direct communication with student workers.

Materials and Scrap Policy	Ensure that the BeAM is as environmentally conscious with their materials for customers while balancing the customers experience in the space	Train workers on policy that puts customer service first when it comes to materials while being resource conscious Train users on design-for-bed	BeAM student workers and BeAM Professional Staff.	Potential risk of this solution is that since the scrapped material policy is not as strict before, this flexibility may lead to a waste of material.
Check System Awareness	Ensure that customers in the BeAM space are aware of the check system for using the laser cutter	Printing/ laminating & training workers on correct use in space.	BeAM Staff	A potential risk to this solution would be taking up wall space that BeAM could be using for other things.
Check System Overhaul	Make sure BeAM staff and student workers understand the check system so customers are getting consistent instruction	Create and define the check system and make sure it includes the activities in each step Employee training on the check system Executing the check system properly	BeAM student workers and staff	Potential risk of this solution is that users who already adapted to the four-check system need to adjust themselves to this change in the checking system, however, adopting the suggestion of increasing awareness of the check system may make up this drawback.

Team Appendix

5. Project Timeline

Our team lead created the project charter that included a column with tasks to be completed, a column to assign group members to the task, and columns to indicate due dates, both internal decided by the group, and external as indicated by assignment due dates for the course. While the external due dates remained the same, as the weeks went along, the internal due dates set by the group were generally followed, but at times extended due to workload for other classes or other life events that brought up the need.

A portion of the charter is provided below:

4.1 Information Gathering Schedule		2/17, Sun	2/18, Mon	2/20, Wed	2/24, Sun	2/25, Mon	2/27, Wed	3/3, Sun	3/4, Mon	3/6, Wed	3/9, Sun	3/10, Mon	3/12, Wed	3/17, Sun	3/18, Mon	3/20, Wed	3/24, Sun
		No Class No Class Break Break Break Break															
Preparation																	
Visit Project Space	All																
Submit Info Gath. Plan	Meg			Due													
Contextual Inquiry																	
Observe Space	All																
Prepare Interview Sessions	All				Due												
Make Student Worker Survey	Meg				Due												
Make Student User Survey	Neil				Due												
Make Professor Survey	Farrah				Due												
Make In/Out TimeSheet	Teresa				Due												
Contextual Inquiry Sheet	Neil/Chenlu				Draft												
Make Full-time Staff Interview	Farrah				Due												
Interview Client & Staff	All								Appoint.								
Contextual Inquiry Students	Mike/Meg																
Contextual In. Student Workers	Neil/Farrah																
Observation (Daytime)	All																
Observation (Nighttime)	All																
Map the Project Space	Chenlu/Farrah																
Make Post Its	All															Due	
Affinity Model	All																
Work Modeling																	
Build Scenarios	Mike																Draft
Create a Physical Model	Chenlu/Farrah																Draft
Build Personas	Meg/Teresa/Chenlu																Draft
Create a Sequence Model	Neil																Draft
Submit Models & Progress	Meg																
Consolidation																	
Prepare Models & Wall Walk	All																
Wall Walk	All																
Project Presentations	Meg/Neil																
Final Exam	All																
Final Projects Due	Meg																

6. Meeting Summaries

Established within the first group meeting, we decided to have a standing meeting on Sundays at 4pm. Following the charter, we would discuss what the upcoming tasks and assign them accordingly. This would also be the time to ask questions, discuss and decide what is needed to complete the next task and agree on the next time we all would meet up.

Proposed by one of the team members, sometimes after class on Mondays and Wednesdays, the group would have a 5-minute stand-up meeting, where we would literally stand as a group, to adhere by the quick and efficient nature of the meeting, and go around the group to discuss where we were on accomplishing our assigned tasks for the week, any challenges we have come across, or how what we learned in class might shift our understanding of the upcoming tasks.

Cognizant of each other schedules, where some students were taking a heavy course load and/or working or doing an internship on top of classes, we all tried to be mindful of ours and each others' time by being clear and concise about our goals for each meeting and accomplishing tasks in a timely manner. Group members were able to discuss not whether or not the upcoming task was within their bandwidth for the week and to reset the internal deadline for the task if group members could not complete the task within the original time allotted.

We generally met on campus as a group, but a few times during the semester, campus was shutdown for holidays/breaks, so we had to make accommodations for meeting spaces.

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7. Data Gathering

At the very beginning of the system analysis, we created 3 surveys: one for the student worker, one for the laser cutter users, and one for professors who send students to BeAM.

The surveys were created with questions in mind that we thought would give us more insight from a specific groups' perspective to gauge satisfaction with the laser cutter and BeAM, and recommendations for improvements involving the laser cutter.

Anonymous Student Worker Survey

On a scale from 1-10 answer the following questions. Please be honest, you will not be penalized for being honest.

How prepared do you think laser cutter users files are before they get in line for the laser cutter?

Not at All

Super Prepared

1 2 3 4 5 6 7 8 9 10

Rate your satisfaction with how BeAM has handled user operation of the laser cutter before the 4 check system for laser cutter users.

Extremely Dissatisfied

Extremely Satisfied

1 2 3 4 5 6 7 8 9 10

Rate your satisfaction with the 4 check system BeAM has recently implemented for the laser cutter.

Extremely Dissatisfied

Extremely Satisfied

1 2 3 4 5 6 7 8 9 10

What are suggestions you have to help with laser cutter user flow?

How are we doing?

BeAM laser cutter user satisfaction survey

Please answer the following questions as honestly as possible. Your answers are anonymous and will help improve everyone's laser-cutter experience!

SPLIT THIS LIKE THE STUDENT WORKER ONE.

1. Rate your satisfaction with the queuing and four-check system used by BeAM to manage scheduling for the laser cutter.

Extremely Dissatisfied

Extremely Satisfied

1 2 3 4 5 6 7 8 9 10

2. If you are dissatisfied, what part are you dissatisfied about, check one or more of these.

- ☐ Time waiting in line
- ☐ Clarity of Instructions on how to use the laser cutter
- ☐ The four-check system
- ☐ The first come first serve system
- ☐ Other _____

OPTIONAL:

3. What are some suggestions for making the queue system run more smoothly?

BeAM Professor User Survey

Please answer the following questions as honestly as possible. Your answers are anonymous and will help improve everyone's laser-cutter experience!

1. How would you rate your classes experience with using BeAM for the class project?

Not satisfied

Very satisfied

1 2 3 4 5 6 7 8 9 10

2. Before assigning your class to an assignment that involves BeAM, do you talk to BeAM staff in advance?

3. How much time do you think your student will spend at the BeAM for their project?

0-1 hours 1-2 hours 2-3 hours 3-4 hours 4-5 hours 5+ hours

OPTIONAL:

4. Is there anything BeAM can do to improve your classrooms experience using the laser cutters?

8. Data Evaluation

We requested data from BeAM specific to the users of the laser cutter systems, which includes the time the user checks in with their OneCard, the time the user checks out with their OneCard, the facility ID, the visit ID, and the description which classified the purpose of the user's visit. The spreadsheet that was given started out with 2,592 fields, with each field representing one user from September 2018 to February 2019.

While the entry time and exit time are recorded, what is not recorded is the time the user actually got on and off of the laser cutter. This information would have been highly valuable to understand the average length of time spent waiting for the laser cutter and the average time spent on the laser cutter itself. We took out the fields where facility ID was 2 because we decided to focus solely on the laser cutter at Murray. Visit IDs were just an ID assigned per visit, not specifically tied to a user the same way a PID would. Descriptions classifying the purpose of the visit were narrowed down to "Personal Project", "Class Project" and "Research" because these purposes were the most relevant to the laser cutter queue system, while other purposes such as "Staff after-hours" or "Makeathon" were categorical outliers.

To make sense of the data for our purposes, we used excel formulas to pull out columns identifying the month, day of the week, and duration of the visit to create the charts and graphs from page nine.

9. Plans for presenting to the client

Our group has already presented to the client our final consolidated models, personas, and the list of our proposed solutions. With ease and feasibility in mind, we noted which solutions may require more a more in depth look before considering implementation, and others that can be immediately implemented. We also plan to send the client all of the data and information used and gathered for the system analysis of BeAM, since the clients noted that they would like to see all of the data we've acquired and created.

10. Team Performance & Results

10.1 Strengths and Weaknesses

The team worked together well overall such that we took the course and project seriously, making sure that we set aside dedicated time for group meetings and meetings with the client. We tried to be as efficient and concise as possible in the meetings and the work we put in, with the understanding that we were sacrificing time out of our weekend to meet regularly and we all wanted to be able to give our clients well researched solutions as a result of the contextual inquiries, models built, and input from the client meetings. To stay on top of things, aside from the standing Sunday meetings, we had a group chat administered through Slack, where we posted meeting notes, upcoming meetings, and for general communication.

That being said, an area of growth for our group was communication where at times members would forget meeting times that were sent through other forms of communication from a while ago, notifications for the app would be turned off, or simply lack of communication. Communication is an integral part of a successful team, and despite technical difficulties and human error, we were able to learn from our mistakes and address the communication issues with one another.

10.2 Lessons Learned

Limit the scope. We learned that it was important for us as a group to clearly define the scope of what we intended to evaluate and proposing solutions that are a result of our evaluated scope. From our meetings, our clients discussed other issues that were tangentially related to the laser cutter queue system and while we made sure that they knew that they were heard, we had to emphasize that those issues were not within our scope to clearly set expectations of what our group would focus on during the semester.

Digital tools are not always the answer. While the BeAM staff noted that they were in the process of creating a digital queue system, we brought up suggestions from the survey responses and contextual inquiries that included implementation of digital tools to improve the flow of the queue system. The clients noted that a digital system that could alert users of laser cutter availability, wait time estimation, laser cutter online reservation system, and other digital capabilities would be ideal, but would require more resources that are not currently available or simply do not fit with the flow of the system.

Listen to the clients. Understanding that our clients interact with this system on a daily basis, we came to realize that some solutions, while seemingly obvious, may have already been tried and tested by the clients or the result is very different from what the team had concluded. For example, some team members originally thought that the time limit for the laser cutter would be a bigger issue since it was implemented in January, but after speaking with our clients, we found that many users actually reach out to the BeAM staff regarding the scrap policy and users generally finish their projects within the new issued time limit.

Model selection matters. Although we each created one contextual inquiry per user and BeAM student staff, each individual models we created exposed breakdowns within the system from different perspectives. We decided to create flow models, sequence models, cultural models, and physical models. The chosen models made sense for us to use especially since the laser cutter queue system involved a lot of structure such as required OneCard check in per user, going through the 4-check system, and then getting on the queue for the laser cutter.