University of California, San Diego **Global TIES**

Course **ENG 100D, Spring 2019**

Instructor **Ryan Mancinelli**

Project Team **Seal Team 7**

Atutu Innovation Space

Design Report

Due: June 14, 2019

Team Members

Goutham Marimuthu, Jaskirat Chahal, Taige Hao, Abigail Manriquez, Winson Dieu, Samuel Cabrera, Jerry Shu

Community Partner

Atutu: A Non-Profit NGO

Executive Summary

Atutu seeks to connect engineering fellows in Myanmar with US students to promote entrepreneurship within local communities. Currently, the engineering fellows do not know what is possible with the tools and resources they have and lack a sense of inspiration due to several institutional barriers (economic, legal/political, socio-cultural) that prevent them from co-ideating with Atutu. Educational institutions within a historical context may have fostered an apathetic attitude to design change. This manifests itself as an issue for Atutu since the engineering fellows in Myanmar are hesitant to propose new design ideas, possibly due to a false sense of inferiority. To correct this, our team has partnered with Atutu to design a maker-space that will enable the two parties to co-ideate effectively by building a library of resources so that users can help themselves - ultimately leading to sustainable change. Alongside the floor plan design, our team has designed a progressive curriculum and roadmap that maps the space as it evolves through time. Modular cost tables have also been provided that uses a bottom-up methodology for cost estimation and meets our client's budget requirements. Our broad aim is to encourage innovative inspiration by empowering the engineering fellows with the tools and resources to correct educational inequity. If successful, this model can be modified and applied to a variety of contexts and regions.

1. Project Management

1.1 Goals & Objectives

Our team has partnered with Atutu to support entrepreneurship in Myanmar. Our client, Atutu, is a non-profit aimed to empower communities of Kachin through the co-creation of community impact. They aim to address educational inequities and alleviate problems caused by such inequities in these communities. By connecting students in the US with students in Myanmar, we aim to promote engineering design, entrepreneurship and creative collaboration. Through cooperation and community empowerment, we aim to facilitate progress through small group collaboration in growing small business models. Our team's design challenge is to create and implement a STEM-focussed curriculum to encourage innovative thinking and a maker-space to promote entrepreneurial collaboration in communities in Myanmar.

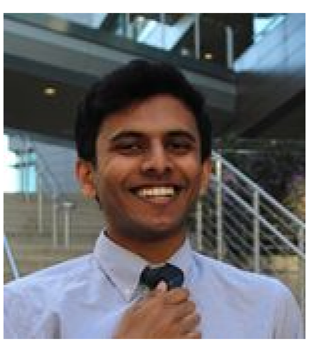
1.2 Approach

The approach we will take is to implement a co-creation methodology within a school curriculum to encourage innovative thinking and promote entrepreneurship in communities in Myanmar. This includes designing a 'maker-space' (a collaborative work space inside schools) which will facilitate the gathering of entrepreneurs and act as a local hub for innovation within those communities.

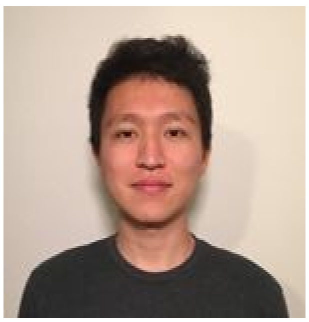
1.3 Schedule

We will divide the project into sub-tasks and assign responsibility to an individual and/or the entire team. First, we plan to sit in on a client meeting and understand their aims and desires. Then we will define the problem and identify the main goals and objectives. Then we will aim to solve it using a human-centred design approach. To efficiently manage the scope, time and cost of the project, a Gantt chart will be used to keep us on track and on schedule.

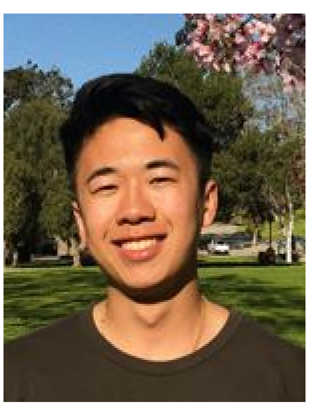
1.4 Team Bios

	Goutham Marimuthu – Partner Liaison gmarimut@ucsd.edu *4th Year Aerospace Engineering* Goutham, the team's partner liaison will ensure that the client and the team are on the same page regarding progress and needs. He has worked on similar projects with Atutu in the past and will leverage his experience with the team.

<table>
<tr><td></td><td>Jaskirat Chahal – Project Manager
jschahal@ucsd.edu
2nd Year Economics

Jaskirat, the team's project manager will monitor project progress and ensure the team meets key milestones. He has experience working in a start-up and will leverage his past experience as a team leader.</td></tr>
<tr><td></td><td>Taige Hao – Scribe & General Designer
tahao@ucsd.edu
3rd year NanoEngineer with a focus in Materials Science

Taige, the team's general designer, will help create designs that answer to the client's needs and specifications. Taige has experience in 3D modelling and 3D printing.</td></tr>
<tr><td></td><td>Abigail Manriquez – Floorplan Designer
abmanriq@ucsd.edu
4th Year Structural Engineering

Abigail, the team's floor plan designer will service the project goal by designing the floor plan and ensuring that designs are up to specifications. Abigail has experience in structural design and modelling software.</td></tr>
<tr><td></td><td>Winson Dieu – UX Designer
wdieu@ucsd.edu
3rd Year Cognitive Science with a focus in Design & Interaction

Winson, the UX Designer, is in charge of orientating the design to be human-centred through ensuring the user flow created is data-driven and natural to use. Winson has a background with doing research with Design Labs and is actively pursuing design projects with impact.</td></tr>
</table>

	Samuel Cabrera – General Designer s3cabrer@ucsd.edu *2nd year transfer Cognitive Science with a focus in Design and Interaction* Samuel, the team's general designer, will help to make sure that the designs are up to specifications that the client needs. Samuel has experience in graphic design, UX design, and web design.
	Jerry Shu – General Designer J4shu@ucsd.edu *4th Year Cognitive Science Major with specialization in Human Computer Interaction* Jerry, one of the team's General Designers will help come up with designs based on the client's needs and demands. He has experience with design thinking and worked on multiple human-centred design projects.

1.5 Stakeholder Analysis

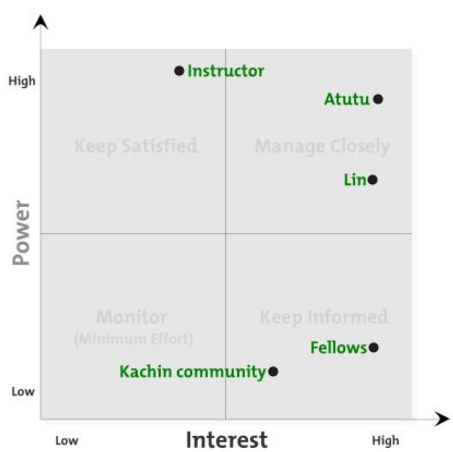


Figure 1.2 Stakeholder Analysis Matrix

Instructor: Ryan, our instructor, has high power over our project as he determines the grade for the team. He has high power over our project, having the ability to cancel the project but is lower interest as the project will ultimately be delivered to the client. We will make periodic updates throughout the quarter to keep him satisfied with our progress.

Atutu: Atutu is our client so they have a vested interest in making sure our project is successful. They have a high amount of power in that they need to approve of our design and ensure that it is implemented effectively. As a result, Atutu will be in close contact with our team and will have regular updates and debriefs so that we are on the same page.

Lin: Lin is the co-founder of Atutu and our main relation to the organization since he is easily accessible due to his status as a TA in ENG 100D. As the co-founder he also has a high interest in the project but he has slightly less power than Atutu as a whole considering that he does not represent the full organization.

Fellows: The Atutu Fellows are the end users of our design. They are the people who will be using and learning from our makerspace in Myanmar. As a result, they have a high interest in the project. However, due to the difficulty in contact between us and the Fellows, they have a low level of power over our design. We want to make sure they understand and approve of our designs as we run through the project.

Kachin community: The community in Myanmar has a vested interest in the success of the project as it will ultimately impact them but they have a low degree of control over the project direction and scope. Language barriers, for example, make it difficult to keep in close contact but we will keep them informed indirectly through Atutu.

2. Problem Definition

2.1 Problem Statement

Engineering fellows in Myanmar need easier access to resources and tools to bolster their confidence and ability to co-create with Atutu and offset the deficit mindset stemming from various educational and socio-cultural issues present in Myanmar.

2.2 Background and Context

2.2.1 Atutu

Atutu is a non-profit organization co-founded at UCSD focused on addressing issues in communities in Myanmar by using a co-design methodology where students in UCSD work with community members in Myanmar who they call fellows. These fellows are recent graduates or college students who are particularly interested in learning engineering principles and the design process to solve community problems. Atutu views the community members as the experts as they have a background in the community and understand their own problems on a firsthand level. By doing so, Atutu aims to put the community at the center of the design process so that the solutions will not disrupt their lives. As a result, their co-design philosophy revolves around acting as engineering consultants where the fellows would carry out much of the design work and Atutu would act as a resource helping them out. However, the co-design philosophy has been difficult to execute since the fellows do not have the engineering background to ideate on their own and the education system in Myanmar has led to a “listen to the experts” mentality where they will listen and answer Atutu questions and follow instructions but not actively participate in the process.

2.2.2 Education in Myanmar

To identify the root cause behind Myanmar’s educational inequity, we explored its’ institutions and historical contexts to understand the rules of the game that guide socio-economic phenomena. Understanding these historical, political and economic trends is crucial in our efforts to design an effective solution.

Myanmar’s current political field is described as “democratization under military control” making Myanmar a hostile environment segregated by military and state (2.4). The role of separation of military and state leads into socio-cultural consequences of participants of “democratization movements silenced or jailed” for speaking in acting out in what they believe in. With that being, this dynamic reinforces the mindset of not questioning authority which is detrimental to innovation and critically thinking. To couple this, Myanmar lags “behind the developed world” with “unqualified teachers, very little resources, and aging materials" which make it extremely difficult to produce students that have an emphasises on education (2.6). The socio-cultural consequences of separation of military and government have created an environment that is not properly equipping to critically learn and challenge the socio-cultural scene.

Myanmar's fixation on military control has hindered the development of its education system and left on the backburner. Its education expenditures in 2011 were 0.8 percent of the gross domestic product (2.2). These expenditures were globally one of the lowest percentages. Sources indicate one of the reasons for limited educational expenditures is due to traditional education organized by the Buddhist monasteries. Traditionally taught by the Buddhist monasteries, children in Myanmar today struggle to access the education that they need in order to succeed in life and move upward in society. The quality of schooling that children have access to is severely lacking due to the government's unwillingness to dedicate resources towards education and the general poor quality of the teachers present at these schools. Even if children in Myanmar have access to education, only 10% of students make it to the 12th grade. This is due to the low passing (<50%) passing rate of the students who take the Basic Education High School Examinations and the selective nature of the exam.

The prevalence of Confucian education philosophy in Myanmar also takes a toll on students' sense of empowerment and belief that the world is malleable (2.7). This ideology coupled with Myanmar's oppressive history and rigid institutions are potential causal factors underlying its lack of innovative organisations. As graduates face great difficulty in entrepreneurship and a lack of opportunities, they often return to unskilled jobs or emigrate in search of a better future (3, 2.8). The 'brain-drain' phenomenon is detrimental to the long-term future of Myanmar.

Historically, Myanmar's lack of legal and fiscal capacity has caused the government to ignore impediments to its economic development. Ambiguous land rights, a restrictive trade licencing system, opaque revenue collection system and antiquated banking system are few of such outdated institutions in need of immediate reform (2.8). The inflexibility of Myanmar's institutions is likely to have caused a sense of apathy regarding government provision of public goods such as education, healthcare and social welfare institutions. Thus, organisations like Atutu are critical in establishing 21st Century institutions that ease access to tools, resources and education.

2.3 User Profile

The interviewees that formed the user persona consist primarily of Atutu members. The Myanmar community member persona consists of comments from Atutu members. Since it was difficult for us to travel and get in contact with Myanmar community members to perform this research, we obtained data from Atutu members who have developed a relationship with the members.

Persona – Myanmar community member – Electrical Engineer

"I want to enhance my electrical engineering skills!"

Age: 22
Education: 4 year college
Location: Myanmar

Bio

- Mia was born and raised in Myanmar. She graduated with honors from Yangon Institute of Technology with a degree in Electrical Engineering. She has been having a difficult time finding a job in her field. Discouraged from job searching, she has decided to work at her parents local goods shop.

Goals

- Enhance skills in Electrical Engineering
- Create sustainable products

Frustrations

- Resources are limited
- Job availability is scarce

Needs

- Platform with accessible resources
- Job opportunities
- Platform to enhance electrical engineering techniques

Relative Knowledge, Skills

- Self learner
- Complex Problem Solving
- Circuit Design
- Instrumentation and Electrical Measurements

Capacities

- No platform to enhance skills
- No Internet to find visual aids on Circuit Design

Figure 2.1- Engineer User Persona

Table 2.1 Engineer User Empathy Map

Say - "I want a job in my field" - "I want accessible resources"	**Think** - I wish I could enhance my skills - I don't want to keep working at my parents local good shop
Do - Searches for jobs, but no luck - Co-ideates with Atutu	**Feel** - Bored working at her parents local goods shop - Happy working with other engineers from the US - Discouraged to express ideas, due to lack of resources

Generated based on Interviewees: Eric Richards (Atutu co-founder); Lin Hein (Atutu co-founder)

Bio
Gabriel from the age of 7 has had to help his family with their business, even though he excels in the sciences he never got a chance to explore his passion for engineering.

Needs
- Stable access to a resource on his own schedule.
- Mentors that he can voice his questions to.
- Learning environment outside of the traditional school format.

Age: 20

Eduaction: College Dropout

Location: Myanmar

Goals
- Be able to learn the fundamentals of engineering to improve his community.

Relevant Knowledge/Skills
- Has learned how to be a "handyman", the capacity to fix things.
- Comfortable with tools.
- Has sparingly learned about engineering.

Frustrations
- Not having the privilege of going to school because of having to help his family earn money.

- Has a drive to learn, but not a platform.

Capacities
- No platform that will accomodate to this infrequent schedule.
- No access to consistent electricity and internet to learn engineering.

Figure 2.2 College Dropout User Persona

Table 2.2 College Dropout User Empathy Map

Say	**Think**
- " I want access to a learning environment that can accommodate to my schedule." - "A platform to exercise and practice his knowledge for engineering."	- With education and knowledge about engineering can provide more for his family - School is a privilege that he does not have the time for

Do	Feel
- Learns sparingly from what resources he can, such as learning how to fix things - A hard worker with a drive to create	- Feels obligated to help his family because without him the business cannot run properly - Does not have equal opportunity in learning because of having to support his family

2.4 Design Requirements

Table 2.3 Design Requirements

Criterion	Requirement
Accessibility	Fellows can easily approach new machinery and learn new techniques without feeling intimidated by the other fellows or by new unseen equipment in the makerspace.
Longevity	The Makerspace is equipped with sufficient tools and guidelines to allow the makers to create recommended projects, design, ideate and build their own.
Sustainability	How long our space is relevant for and ways we can avoid downtime or times where things are broken and remain broken.
Inclusivity	Members from different backgrounds could face potential difficulties working together due to social imbalances, how would the members feel working with a stranger or someone of a different gender?
Usability	Despite giving users the tools and resources needed to create something, how likely are they to pick up these resources on their own and figure out how to use them or what the purpose of the tool is?
Cost/Feasibility	Are we able to deliver our vision to the fellows in Myanmar within the budget of 5-10k and how feasible are the target goals we have for the first step of our design?

3. Concepts

3.1 Existing Solution Analysis

Our research into existing solutions revealed various organizations aimed at tackling issues similar to those incorporated in our problem statement. The landscape of current solutions, and opportunities for increased positive impact is minimal. However, the product produced from these non-profit organizations lack in either reliability or accessibility.

Table 3.1 Existing Solution Analysis

Organization: Kër Thiossane **Problem:** Community does not have access to resources to innovate and execute design ideas **Solution:** Kër Thiossane created DefkoaNiep makerspace in Senegal and provide workshops/training for the community members. **Pros:** ● Access to readily resources to innovate and execute designs ● Opportunity to gain technical skills and entrepreneurship **Cons:** ● Equipment unreliable	Kër Thiossane 
Organization: Open Source Maker Labs **Problem:** Students in San Diego have a lack of experience before entering the job market. **Solution:** Equip makers with tools, resources and a workspace to collaborate on ideation and creation. **Pros:** ● Enable access to tools, resources and a workspace ● Provide high-quality technical workshops **Cons:** ● Expensive membership ($1176/year)	OSML™ 

Organization: Phandeeyar
Problem: A shortage of tech knowledge and skills in the labour supply due to Myanmar's politically turbulent history.
Solution: Establish a seed accelerator that leverages technology to accelerate growth and development of local start-ups.
Pros:

- Provide a six-month training program
- Provide funding approx. $25,000

Cons:

- Access to resources is competitive
- Claim a 12% equity stake

3.2 Concept Generation

Community Development focused floor plan:

For this floor plan, we wanted to focus on the goal of improving the local community in Myanmar by providing the fellows with tools and a space to do so. This building has a community bulletin board on the outside, which allows members of the community to come to the maker space with issues and problems that they can ask for help with, which the fellows can tackle using the maker space. This bulletin board provides funneling system for the needs of the community to the doors of the makerspace. On the outside of the space, we made space for a community garden and tool shed to facilitate outdoor work and design solutions that involve gardening and farming. For this design specifically, we wanted it to have some sort of windows, so that the people outside could see in, to help facilitate a sense of trust between the community and the makerspace. Inside of the makerspace, immediately by the door is a storage area where fellows may place their belongings, take out clipboards and paper to collect information in the field with, and iPads. The iPads are easier to use tool for looking up information for solutions, that removes a lot of the overhead involved with using technology and searching. For this design, we focused primarily on usability and efficiency for coming up with solutions. The floor plan includes two large rectangular movable tables, four smaller round moveable tables, two moveable whiteboards, and one large stationary whiteboard. The modularity of these pieces of furniture allow the fellows to modify the space to suit their needs. At the opposite wall is a workbench with tools focused on community improvement, such as woodworking tools and sewing machines. We also included a rest area as research showed that ideas are improved after taking a short nap.

Hobby Based/Incubator focused floor plan:

For this floor plan, we wanted to focus more on individuality and a space that would allow fellows to pursue design projects that they would be passionate about. Along one wall is a whiteboard for ideation, and a couple computers and iPads. the iPads as mentioned in the community development focused floor plan are an easy-to- use tool for looking up information that the fellows may be curious about. The addition of the computers is to promote pursuing interests involving computers, such as programming Arduinos or even just general typing. We included moveable tables and moveable whiteboards to maintain modularity within the space, allowing for a variety of layouts as the projects demand. There is a separate area with storage lockers, for this design we looked into a design for the storage area similar to insta-crates, to save space, allow for modularity, and give fellows the ability to store objects. This design includes a double door, to allow more space for larger projects to move in and out of the space. Against one of the walls is a workbench with a larger number of tools and potential project/workshopping materials. There are hand tools, soldering irons, a sewing machine, and a variety of interesting hobby projects with various levels of "difficulty" to allow fellows to start from a basic challenge and move upward. An example of this would be breadboards, Lego Mindstorm and Arduinos. Within this space is also a rest area, as it was one of the important parts that we incorporated into all of our designs, like the modular tables and whiteboards.

Professional Development focused floor plan:

For this floor plan, we chose to take all of our crazier ideas and incorporate it into a space that would promote professional development so that fellows in Myanmar would be able to find work outside of Myanmar and improve the economy by sending money home. This floor plan is more outlandish but has led to improvements in other floor plans by analyzing the stranger ideas. On the outside of the building is a parking area for various transportation devices, such as cars and scooters, the entrance uses a revolving door for accessibility improvements, as well as to make the fellows more excited at entering the makerspace. Since this space is professionally focused, there is a whiteboard and a projector screen on one wall, with moveable tables and chairs facing the wall in order for fellows to learn from Atutu members visiting or each other. Along another wall is a computer literacy corner. There are several computers, computer literacy tools such as textbooks and tutorials translated into Burmese. There are also other computer related tools there, such as Arduinos and breadboards. Along the other wall is a shelf with books for professional development, as well as motivational books that help fellows build confidence in the working world. This space is separated into two rooms, the room previously described, and the "machine shop" where more heavy duty and louder work is carried out. This space is high noise, so the walls would be sound reducing in order to improve learning in the "classroom" space. In the machine shop there are heavy duty tools such as bandsaws, welders, table saws, lathe-milling machines and other engineering focused tools. There are fire extinguishers in this room along with instructional material on how to use fire extinguishers in case of an accident. An extension of the building is a conference room where fellows can meet with partners to discuss projects and other prospects, as well as a rest area with a jacuzzi.

Along all of the walls in all of the rooms are posters with art and motivational content in order to inspire creativity and positivity within the makerspace

3.3 Concept Evaluation & Selection

Community Development Focused Capture Grid

What Worked? ● Bulletin board/schedule is great for allowing community engagement ● Modularity of tables and equipment	**What can be improved?** ● Specifying what the rest area consists of
Questions ● What about projects that are too large for an indoor space?	**Ideas** ● Having an area outside/connected for auto repair work

Hobby Based/Incubator Focused Capture Grid

What Worked? ● Great to have a computer station to search for how to's and promoting the learning of digital and electronic media	**What can be changed?** ● Maybe having the computers moveable so that they can be moved to the workstations(i.e. laptops)
Questions ● What is the benefit to a mounted whiteboard as well as moveable ones?	**Ideas** ● Having guides for building up knowledge from breadboards to the Lego Mindstorm and Arduino

Professional Development Focused Capture Grid

What Worked?	**What can be improved?**
● The main area is very traditional, classroom- esque	● Removing the jacuzzi, parking spaces, and revolving door

Questions	Ideas
• What if multiple projects/concepts wanted to be worked on at once? • Who decides what will be taught? • Who are the professionals that come in to teach? • Would the machine shop or the presentation area be closed off if the other room is in use?	• Sectioning off the space so that numerous workshops can be taught

Design Requirements:

1. Ease of learning curve: Learning curve needs to account for fellows learning level and give them scaffolding methods to grow.
2. Ability to codesign with Atutu: Fellows should be able to start a variety of projects with the tools available and then ask Atutu for help and feedback when necessary.
3. Community Engagement: Fellows' projects should benefit the community.
4. Safety & Reliability: Makerspace should be safe to learn in and the tools should require low upkeep.

Criteria	Weight	Concept 1	Concept 2	Concept 3
Ease of Learning Curve	3	2	3	3
Codesign with Atutu	5	2	5	2
Community Engagement	2	5	3	2
Safety & Reliability	5	3	5	3
Weighted Totals		12	15	10

Out of our three floor plan models in deciding on the hobbyist/incubator makerspace, we care to the rationale that in allowing the Atutu fellows to not only explore their interest but to also curate confidence in their ability to perform through developing their skill sets on projects they find purpose and enjoyment from. One of the most important factors of our intention with the maker space is to create a platform for fellows to grow as an individual and feel confident in their ability to contribute and co-design. With that being said, with the other two options of the professional development and community based maker spaces, the professional development was a radical iteration/exploration of designing without constraints while the community based space was initially our go to; in exploring the potential butterfly effects of the community based space, we came across the possibility of imposing projects and unintentionally restrictive them to curating their true pursuits with what they feel passionate about. As a result, we chose to move forward with the hobby/incubator space to allow them to curate passion for projects that are purposeful and meaningful to them. This may be a source of confidence in the prospective future to collaborate and bring third order change to how they view the educational hierarchy.

4. Analysis & Testing

4.1 Overview

User testing and analysis enabled our team to critically evaluate our proposed solution prototypes. Analysis of feedback from our key stakeholders allowed us to assess the extent to which our prototypes met our self-imposed design requirements. We leveraged a variety of evaluation methods to test key metrics and observed resultant values that met and/or exceeded target values. Research of survey materials on makerspace design, testing with proxy end-users and evaluation of our floor plans allowed the team to assess the viability of each prototype and modify the design to improve on each future iteration. This analysis summary provides a snapshot of the viability of our current prototype; despite meeting some of our targets, there exist opportunities for further enhancement.

4.2 Desirability & Usability

In order to measure how desirable and usable our solution is we followed table 4.1 and evaluated based on the criterion of accessibility, longevity, sustainability, inclusivity, usability and affordability. For each of these criteria, we came up with different tests and approached different users to test them with in order to get feedback and build on our design.

For accessibility and longevity, we simulated our floor plan to four different users and received feedback and recorded activity. For accessibility, we used the number of tools interacted with as a quantitative metric for accessibility/approachability. For qualitative data, we received different feedback mentioning how something that the user had not seen before (the community garden) would intrigue them enough to get them to approach it, and feedback from the other users that they would focus on something that they have some familiarity with and that they would seek to improve in that area (soldering). We aimed to have our user tests use 3/4ths of the tools, but each user test ended up using about 2/3rds of the tools instead, with the combined tests covering more than 3/4ths of the tools. For longevity, we relied on quantitative data by having our user testers rate each tool for usefulness on a 10 point scale. We aimed to achieve at least an 8 in every single component/tool's evaluation.

For longevity testing, we asked users to rank the importance or usefulness of each component of the makerspace floor plans on a ten point scale to help determine which parts of the space were must haves and could haves. We also presented users with a list of potential tools we planned on including in the space and asked them to check off tools they had experience using, O tools they knew of but had not used before, and X out tools they had no familiarity with. Unfortunately for longevity testing, the results deviated greatly from the expected value of 80%. User testing revealed that only around 53.59% of the components placed within each of the three floorplans were relevant or important for the longevity of the makerspace. It shows potential areas where we could greatly reduce the cost of the space itself, or places where spending is emphasized. Fortunately, most of the tools presented to users were ones they were already familiar with and those that were not tended to be tools that were more obscure. We hope to address this discrepancy in future meetings and address any potential shortcomings with our design.

For the sustainability aspect, we conducted user interviews gauging their confidence in the ability to recreate the skill taught from the static graphic and the video provided and asked to record their journey map to see how they internalized the information. Through this, the journey map offered insight into how we might improve the mediums we provide the information. Quite evidently, the contrast between the dynamic vs linear journeymap showcased a discrepancy in the ability to recreate the information. From user testing it revealed that from our expected target value of 83.3% to the actual 49.83% is a direct result of the user test cases being on two extremes, with one result being $5/6$ rating on the confidence scale, while the other being $1/6$. To build on this, the proposal for this section is to conduct more user testing based on the information we collected to bridge the gap between 49.83% and 83.3%. Our goal moving forward to address the Atutu fellow’s needs is to build on our insights we collected from these user journey maps to improve learning flow for the sustainable knowledge system we hope to implement.

For inclusivity, we collected data with a survey on inclusivity to construct a rating on a 5 point scale. Quantitatively, we aimed to achieve a 4 out of 5 rating across the survey, which we did get.

Qualitatively, we got feedback into inclusivity improvements, with feedback mentioning that an initial impression is important, establishing trust, keeping everyone on the same page and operating in smaller groups would help boost perceived inclusivity.

For usability testing, we made prototype instruction manuals and measured test subjects ability to follow the instructions without issue. To quantify our findings, we counted the number of times they asked questions and the amount of time it took them to get through the instruction manuals. We aimed to have 0 questions asked in a 10 minute time frame, which we were able to achieve.

For affordability, we researched survey materials and local suppliers to generate a bottom-up estimate of the cost of the tools, equipment, materials and parts to outfit our makerspace according to the floor plan. Our client advised a budget constraint of $10,000. Analysis of cost estimating methods generates a ballpark estimate of between $5000 and $10,000 dependant on the specialisation that will be accomodated. The minimum cost of outfitting the space with the essential tools and materials is estimated at $5000 with the assumption that everything will be bought new. With a view towards future enhancement of the space, we estimate the total cost of tools, equipment, materials and parts will run up to a total of $10,000 - well inlign with our client’s budget requirements.

Figure 4.2 (see appendix)

4.3 Feasibility & Suitability

In terms of the resources that are available to create the makerspace, the only resources that would have to be sourced outside Myanmar would be the technological aspect of the Makerspace, but beyond this in constructing the makerspace after consulting Lin, there will be a designated space for the actual floor plan to be implemented into. For the feasibility of constructing the physical space is highly probable but with importing task enabling tools such as: power tools, computers, and whiteboards would be sourced in an unconventional fashion through "sneaking" in the necessary technological tools to satisfy the value aspect of the makerspace to the Myanmar fellows. The most necessary step to the feasibility portion is logistically setting up a system to transport the tools to the location. To substantiate our findings of feasibility, in terms of the expected cost of creating the makerspace, we estimated that the tools needed to construct the floor plans would be well within budget. The minimum cost to set-up and outfit the space is within our target value with a view towards successive iteration that is also within our proposed budget.

4.4 Sustainability

Ecological Sustainability

1. Goal and Scope – The goal of this LCA is to gain insight on how ecologically sustainable our solution is.

2. Inventory analysis – Since we are utilizing and already built structure and transforming it into a makerspace, our inputs are increased. Refer to flow chart (*Fig 4.2*) for inputs and outputs of the solution.

3. Impact assessment – The solution is created mostly of pre-assembled machinery, tools and furniture. The solution has inputs such as energy usage and one-time resource transportation. The overall cost of resource transportation in terms of carbon dioxide emitted is 20 pounds. The energy usage cost in terms of kilowatt-hours is 17.3kWh of electricity. The makerspace studio will not be open 24/7, we intended to have it open during business hours and use natural lighting throughout most of the day to reduce energy consumption. The machinery also requires occasional maintenance which may have a negative environmental impact due to the disposal of old parts.

4. Interpretation – Since the makerspace has machinery that emits greenhouse gases, the environment may also be hindered by air pollution. As compared to a typical office building, the fellows will constantly be working with machinery/tools that release greenhouse gases.

Figure 4.3: Inputs and Outputs of the Makerspace (see appendix)

Analysis of survey materials on makerspace design and consulting local suppliers, allowed us to generate a bottoms-up estimate for outfitting the makerspace with tools, equipment, materials and parts to support a variety of specialisations. The estimated cost to set-up the makerspace is a minimum of ~$3000 with the assumption that equipment and materials will be purchased new. This does not account for equipment or materials that are already existing, built, donated or salvaged. This fixed cost encompasses set-up cost of creating a space that is furnished with necessary essentials. An additional fixed cost of ~$2000 contributes towards outfitting the workshop with essential tools for a variety of maker projects and basic materials and parts. The incremental cost of adding a woodworking, metalworking and electronics specialisation is an additional $1000 each. Computers and labour add an additional $1000 each. Range estimating generates a minimum cost of $5000 and a maximum of $10,000. This estimate is well within our client's budget requirements and with a view towards future enhancement of the space, allows for a successive iteration to be built within cost estimates. As our makerspace evolves and our users progress to more technical projects, cost affordability will be maintained. Once fixed costs of setting up and outfitting the space have been incurred, the marginal variable costs of materials and maintenance are accounted for. Our solution improves user's financial security as using the makerspace will be at no cost to the user but will allow them to build their skills and expertise to enter the skilled labour market.

Equipping our users with skills and expertise improves their self-sufficiency while ensuring economic independence. Our solution is thus affordable and economically sustainable.

Socio-Cultural Sustainability

A major limitation our group face was having access to our end users. Unfortunately, the community was not able to play a determinative role in the design process. However, our group went to great lengths to accommodate the fellows interests. This included conducting user testing with people whom fit our user profile. Although, 15 people cannot represent the community in Myanmar, obtaining their feedback allows our team to understand what the fellows need in further solution implementation.

We believe that the user will be able to harness, replicate and improve the solution. We will provide both the end user and our partnered organization with the information on manufacturing, budget and possible supplier resources. With this information they have the ability to execute/replicate our design solution with the possibility of improvement. We will supply our partner organization with the design of the makerspace in order to replicate it. The design will include arrangements of the machinery and furnishing. End users have the ability to harness the solution by having the accessibility to the resources of the makerspace, and dictate what prototypes/designs are implemented with these resources. Our partner organization has the ability to harness the solution by having full ownership of the makerspace and the ability/accessibility to implement design/prototype solutions. The end user has the opportunity to improve the solution by providing feedback to our partner organization. The end user and partner organizations have the ability to modify/improve any design specification.

Our solution is culturally appropriate and promotes social justice. Our solution allows our end users the accessibility to resources and technologies. End users have the ability to acquire new skills and/or improve skills. This opportunity will provide empowerment within our end users. Additionally, our solution opens the opportunity of socio-economic status advancement with the opportunity to attain careers. Our makerspace is intended to promote inclusion among community members of Myanmar. Our end users will create a learning community within the makerspace and improve awareness of their self potential. Overall, we believe our solution is socio-culturally sustainable in Myanmar because the community lacks access to resources and a platform to implement/execute designs and skill building opportunities.

5. Design

5.1 Overview

Our makerspace seeks to provide the Atutu fellows in Myanmar with the tools they require to further their education so that they can appropriately codesign with the Atutu members in the US. By providing active learning curricula and a variety of tools, the makerspace shall focus on building curiosity amongst the fellows and giving them the resources to ask Atutu questions or figure out answers themselves. The design of the makerspace consists of a floor plan to accommodate computers, workbenches, and areas for tools and collaborative learning. The design will also have a cost breakdown and an implementation structure so that Atutu can test for learning objectives and implement further machinery when they feel it is necessary. In addition, example curricula will be provided with key aspects that we believe are important to bring out active learning and a more cohesive knowledge base. These aspects include a practical set of instructions, an insight into the theory behind the project, and a set of questions to promote further creativity in designing.

The makerspace would start out simple and small with computers, a set of tables, and simple tools and lessons. By having learning objectives and various avenues to practice creativity, Atutu will be able to check in and follow the roadmap for next steps in the design. The detailed design will go deeper into each of these aspects and a cost breakdown of the model is provided.

5.2 Detailed Design

Floor Plan

The makerspace design provides the Fellows of Myanmar a platform and resources to successfully co-design with Atutu. The makerspace designed is approximately $1000\,ft^2$. These dimensions were derived from existing makerspaces. The makerspace includes double doors and three windows to allow maximum natural light to enter. Refer to Figure 5.2.1 for the following descriptions/locations. Within the makerspace walls at the northwest corner it includes a computer area with three computers and a power supply. The number of computers is based on the Fellow’s member size. Two mounted whiteboards on the south and west walls are included to promote creativity and allow for the fellows to picture/write future designs. A rest area; two sofas with a coffee table, was included in the northeast quadrant. South of the rest area are two workbenches, drill press, dust vacuum, and a band saw. These resources are necessary for creating prototypes and implementing designs. The far south quadrant includes cabinets, storage cubbies, and a sink. The storage items were included to provide an area where the Fellow's can store on-going/finished projects. The sink was included to promote hygiene and provide safety precautions. Additional workbenches and tool cabinets in the southwest quadrant are provided for additional space and resources to execute designs. A 3D model is provided for visualization of the makerspace in Figure 5.2.2.

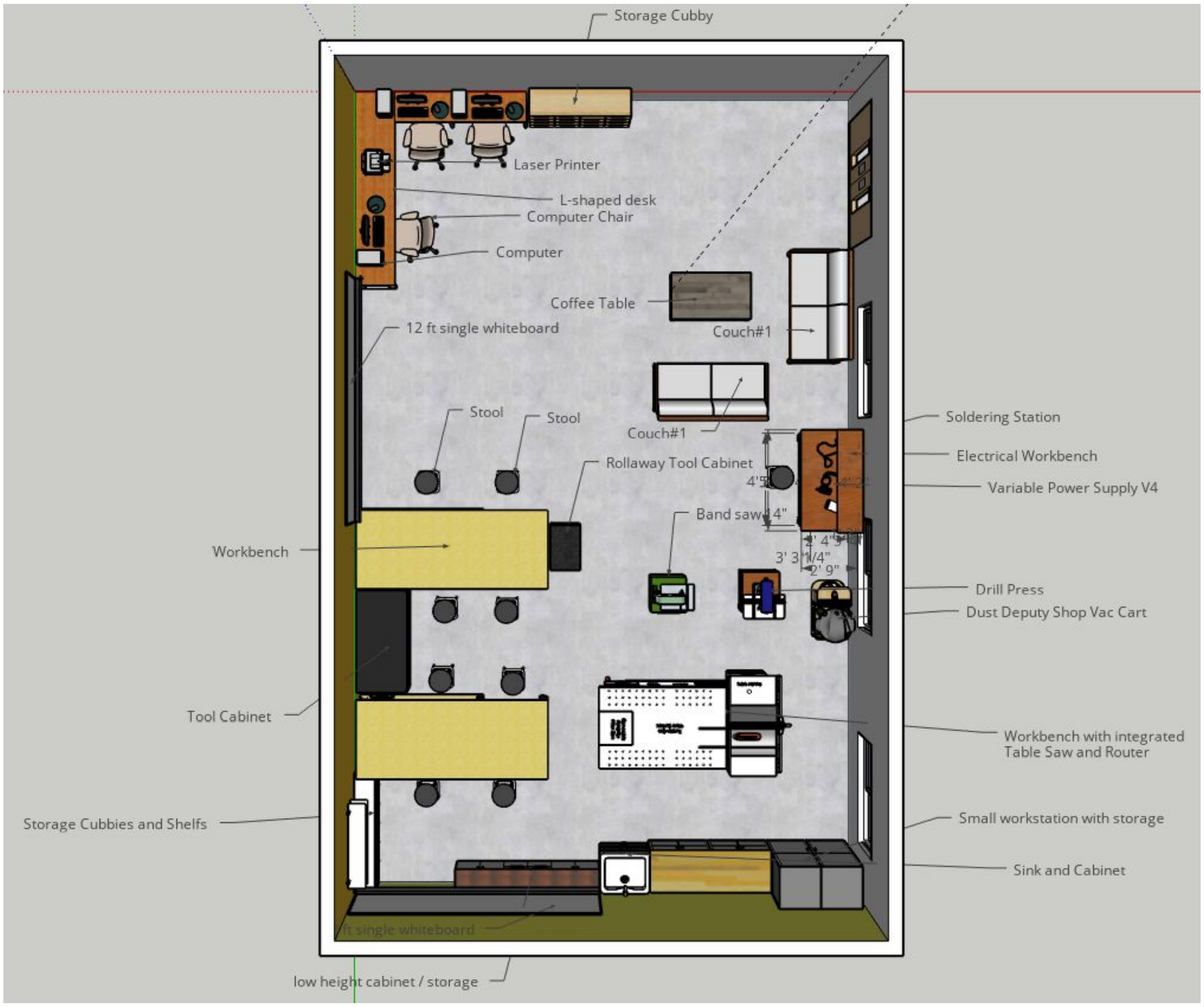


Figure 5.2.1: Floor Layout of the makerspace design

Figure 5.2.2: 3D model of the makerspace design

Full viewable file can be found in the final prototypes folder and can be opened using the Sketchup Web App

Cost Tables ([Cost Tables.xlsx]**)**

Research of survey materials enabled us to generate accurate cost estimates using a bottom-up methodology. A modular breakdown of costs is presented in Figure 5.2.1. Alongside separation by module, there is a division between the Basic and Intermediate levels. This cost estimation approach allows our clients to make an informed decision on final makerspace design based on each module and level. As our design constraints are currently undefined, our estimations will empower our clients to make an informed decision once the space and budget constraints are declared. Each module is comprised of a corresponding list of materials and quantities for a classroom of 25 students. Therefore, in Figure 5.2.2, our cost totals are multiplied by a factor of 50% to account for the number of fellows Atutu currently works with, while allowing for room for expansion. Order of magnitude industry estimates like these are typically subject to an accuracy of +/– 30% (2.9). Further key assumptions forming the foundation of our estimates are that consumables and upkeep are based on 70-100 hours a week, that the makerspace starts from bare walls and that all equipment is bought new. It doesn't account for existing, built, donated or salvaged equipment or materials and doesn't account for construction or operating costs (ie utilities, staffing etc). The estimated number of labour hours for construction of the space is currently undefined, but minimum wage in Myanmar is $3.20 as of 1st June 2019 (1525 MMK/USD). Our estimates show that the design meets our feasibility requirement, given our budget of $5,000–$10,000.

Workspace	Basic	Intermediate
Tools & Equipment	$ 3,326.00	$ 3,644.00
Subtotal	$ 3,326.00	$ 3,644.00

General	Basic	Intermediate
Tools & Equipment	$ 1,830.00	$ 2,830.00
Materials & Parts	$ 729.00	$ 990.00
Subtotal	$ 2,559.00	$ 3,820.00

Woodworking	Basic	Intermediate
Tools & Equipment	$ 1,047.00	$ 1,894.00
Materials & Parts	$ 88.00	$ 164.00
Subtotal	$ 1,135.00	$ 2,058.00

Metalworking	Basic	Intermediate
Tools & Equipment	$ 766.00	$ 3,702.00
Materials & Parts	$ 702.00	$ 954.00
Subtotal	$ 1,468.00	$ 4,656.00

Electronics	Basic	Intermediate
Tools & Equipment	$ 596.00	$ 1,395.00
Materials & Parts	$ 211.00	$ 302.00
Submodule: Microcontrollers & Robotics	$ 595.00	$ 1,311.00
Subtotal	$ 1,402.00	$ 3,008.00

Textiles	Basic	Intermediate
Tools & Equipment	$ 332.00	$ 821.00
Materials & Parts	$ 140.00	$ 278.00
Submodule: Soft Circuits	$ 66.00	$ 232.00
Subtotal	$ 538.00	$ 1,331.00

Computers	Basic	Intermediate
Tools & Equipment	$ 3,882.00	$ 4,773.00
Subtotal	$ 3,882.00	$ 4,773.00

3D Printing	Basic	Intermediate
Tools & Equipment	N/A	$ 2,240.00
Subtotal	$ -	$ 2,240.00

Laser Cutting	Basic	Intermediate
Tools & Equipment	N/A	$ 11,812.00
Materials & Parts	N/A	$ 330.00
Subtotal	$ -	$ 12,142.00

CNC Cutting	Basic	Intermediate
Tools & Equipment	N/A	$ 5,740.00
Materials & Parts	N/A	$ 76.00
Subtotal	$ -	$ 5,816.00

Figure 5.2.3: Cost Breakdown

Totals

Basic	Intermediate
$ 14,310.00	$ 43,488.00

Scenario #1: Workspace + General + Electronics

Mult. Factor	Basic	Intermediate
100%	$ 7,287.00	$ 10,472.00
50%	$ 3,643.50	$ 5,236.00

Scenario #2: Workspace + General + Woodworking + Metalworking + Electronics

Mult. Factor	Basic	Intermediate
100%	$ 9,890.00	$ 17,186.00
50%	$ 4,945.00	$ 8,593.00

Scenario #3: Workspace + General + Woodworking + Metalworking + Electronics + Computers

Mult. Factor	Basic	Intermediate
100%	$ 13,772.00	$ 21,959.00
50%	$ 6,886.00	$ 10,979.50

Figure 5.2.4: Cost Totals

Lesson Plan

Because the makerspace cannot initially encompass all of our ultimate design requirements, we decided to come up with an initial design with specifications, as well as a roadmap of where we want the design to be at various points in time, as well as how the makerspace will ultimately end up. To that end, we want to supply the engineering fellows with initial tools that allow them to progress towards the ultimate goal of being strong designers capable of rapid prototyping and ideation. Because of the nature of lessons and the shifting goals of different engineering fellows, we came up with a guideline model for lesson plans with examples rather than several lesson plans without guidelines. This way, Atutu can design future lesson plans as needed according to our model, which will allow every lesson to smoothly transition into the next and promote retention and conceptual understanding.

Lesson plans should teach how to carry out projects, but also the conceptual backing behind those projects. By promoting an understanding of a concept at both a low level (how it works) and a high level (how it can be applied to other things), engineering fellows will be able to carry out the project with more confidence, and extrapolate the knowledge from that project to future more advanced projects. The different lessons presented should start from a basic concept, and ramp up to more difficult concepts that require knowledge of previous more basic concepts. One such example of this would be projects involving breadboards eventually transitioning into computer programming with lego mindstorms, advanced wiring projects, and arduinos as in between steps, and computer literacy as a side requirement.

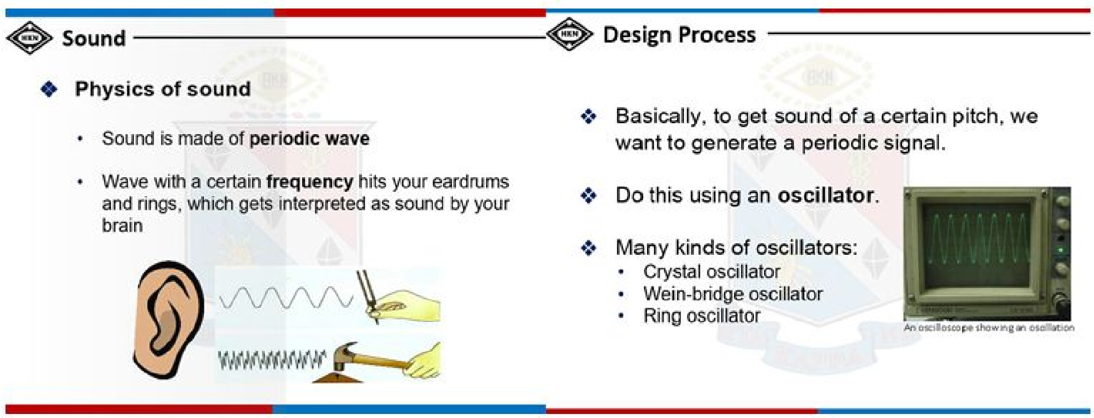


Figure 5.2.5: Conceptual explanation coupled with practical execution, courtesy of mini keyboard workshop lesson plan developed by Samuel Sunarjo and Jahya Burke for Eta Kappa Nu

The above figure is an example of our lesson plan guidelines. It presents the conceptual backdrop for an idea, and then the practical application of that knowledge. After being armed with this knowledge, the lesson applies it to mini keyboards, and the students are able to apply it to future larger projects. As engineering fellows develop more skills and a greater understanding of more fields, they are able to apply them all in more detailed interdisciplinary projects. Alongside this, engineering fellows will develop a greater interest in learning other areas because they are getting a holistic picture of the conceptual backdrop.

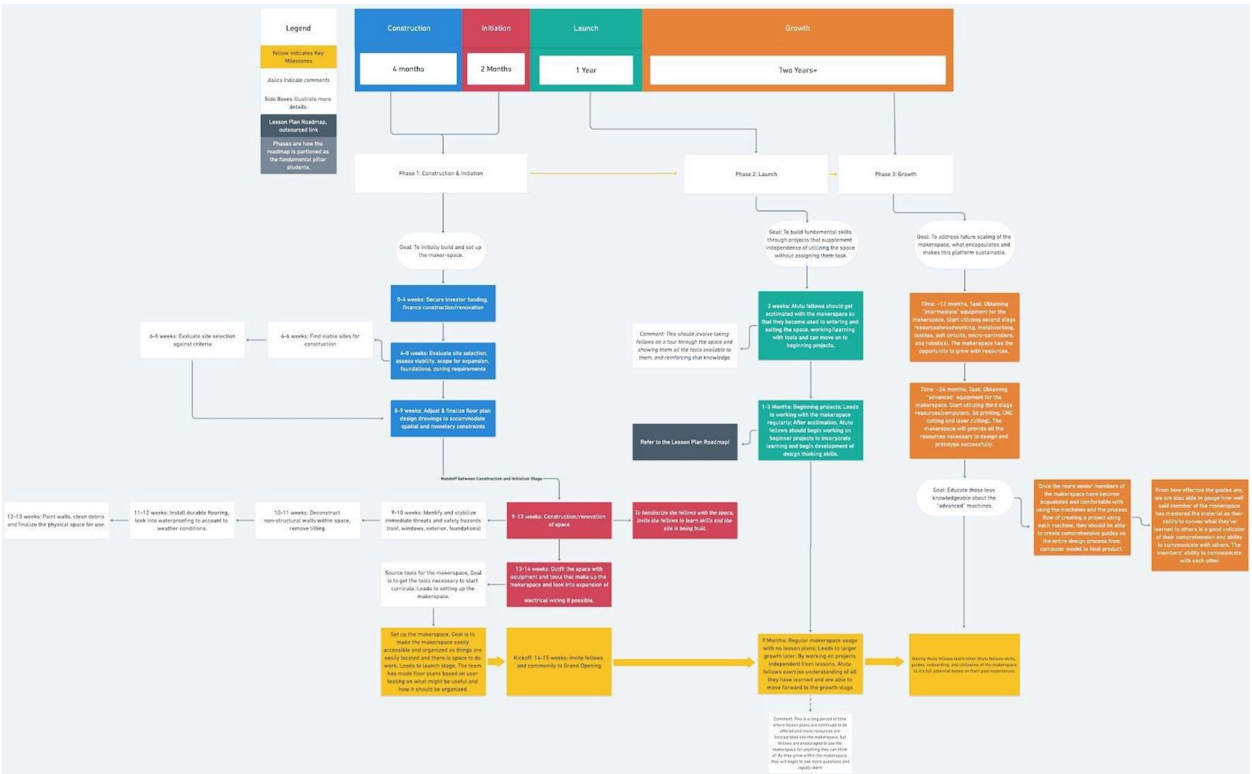
This ties into our roadmap by using lesson plans to approach our later stage makerspace where engineering fellows are interested in and take the initiative in learning. By that point, they should have a strong conceptual understanding of how to use and apply many of the tools that are available to them, and can easily figure out new ones with the proper resources. Goals in mind with lesson plans: is addressing sustainability of the space, require old fellows to teach new fellows the skills and knowledge they acquire, issue of third order change for co-designing and not relying on 3rd party such as Atutu, and eventually there reaches a ‘pivot-point’ after several cycles of fellows where they can begin teaching themselves.

Figure 5.2.6: Proof of Concept: Lesson Plan Roadmap

Also viewable as a separate image: Lesson Plan Roadmap

6. Implementation & Impact

6.1 Implementation through Roadmap



[Overall Makerspace Roadmap]

Fig 6.1 Resource Assessment							
Distribution	Activities	Capabilities	Responsibilities				Still Needed?
			Design Team	Partner Org.	Funders	External	
After we present our design of a curriculum and the Innovation Space, Atutu will follow up by designing a building to allow the fellows to co-create with Atutu	Physical Space	Space procurement	X	X			Implement design to a tangible space
		Interior design	X	X			
		Cleaning + Maintenance		X		X	
		Financing			X		Certification programs translated to Burmese
	Curriculum	Creation of program	X	X			
		Training of fellows		X		X	Transition of Makerspace to allow Community Engagement
		Feedback/Evaluation		X			
	Inventory	Library Resource (Laptop/router/etc)		X			How to make the space monsoon season-proof
		Electronics		X			
		Hardware		X			
		Power tools		X			
	Maintenance	Operating Costs		X	X		
		Tools and Materials		X	X		
		Consumables		X	X		

[Resource Assessment]

Stakeholder Strategy

The strategy to engage stakeholders who have high interest and high power within this project is to provide them with our final project files, road maps and schedule meetings as needed. It will keep the stakeholders engaged by providing the stakeholders with detailed information and specifications of the makerspace/lesson plans. Road maps can be used for reference that provides a specific time line and allows the stakeholders to stay aligned with the timeline. Meetings will be used to address any concerns and provide consultation. These meetings will keep the stakeholders informed and guided to stay aligned with the project goals.

An engagement strategy for stakeholders with low interest and high power is to supply them with pertinent information. These types of stakeholders do not need heavily detailed planning information. The stakeholders will be kept satisfied by providing them with regular progress updates and addressing any of their concerns.

The strategy to engage stakeholders with high interest and low power within this project is to provide them with publicizing information. This form of engagement will keep them looking forward to the projects progress despite not being able to provide input. The main form of publicizing any information is on our partner organization's website. Additionally, surveys will be distributed to promote stakeholders involvement, input, and influence.

An engagement strategy for stakeholders with low interest and low power is providing the stakeholders with promotional/publicizing information. This form of engagement will promote the project and the possibility of higher interest in the project.

6.2 Failure Analysis

Failure Modes and Effect Analysis (FMEA):

Failure Mode	Effect(s)	Severity (1-10)	Occurrence (1-10)	Detection (1-10)	Risk Score	Action
Can’t secure funding	Cannot build makerspace	10	4	1	40	Acquire alternative sources of funding
Can’t secure a suitable site	Can’t build makerspace	7	2	1	14	Propose alternative design (shipping containers)
Codesign issues prevail	Lack of collaboration	6	3	4	72	Redesign curriculum
Fellows reject makerspace	Makerspace isn’t used	8	4	2	64	N/A

Fellows don't progress	Learning outcomes are	6	6	3	108	Re-evaluate curriculum &

6.3 Monitoring and Evaluation Plan

To evaluate and monitor the progress made by the engineering fellows and the overall success of the makerspace itself, we plan on conducting weekly surveys and questions with the fellows to determine potential problems with the space itself or issues that the fellows have encountered while using the space. From this feedback, we hope to address any shortcomings with our provided solution and fine tune it to better align with the fellows needs. The idea of surveying and questioning would also extend to the members of Atutu who are co-designing with the fellows in order to gauge their thoughts on how effective the makerspace is in helping the fellows codesign with them. We hope to incorporate progress markers that the fellows are expected to meet when they're undertaking a lesson plan or when they're working on their own projects. This will be done to ensure that time spent in the makerspace is utilized efficiently while also providing short term attainable goals to the fellows as they progress through a lesson plan to boost motivation and confidence. Later on in the timeline, we plan on having the more experienced senior members of the makerspace create guides or curriculum on how to safely operate a machine or to explain the design process needed to come up with a project using the resources provided by the makerspace. The guide or lesson's ability to effectively convey the correct information to others would be representative of both the senior member's mastery of the machine or design process and their ability to communicate with others. From this, we hope to also improve the member's ability to communicate with each other effectively and develop strong communication skills to supplement the other skills they'll learn at the makerspace.

6.4 Ethical Analysis

Our solution aims to address the educational inequality in Myanmar and empower local fellows with the tools, resources and knowledge to pursue projects on their own. To this end, the makerspace provides a place of learning and ideation for the fellows. This should benefit Atutu by progressing their goals and pushing their engineering fellows to come up with their own design solutions. This benefits the engineering fellows by giving them the tools to combat their education system and close the gap between them and the rest of the world. As they gain knowledge to use the tools, this should feed back into the community, with the fellows able to use the makerspace in order to come up with solutions to local problems.

Some potential problems of this makerspace are the introduction of new technologies and tools into the local environment, as well as potential waste discharge from power usage and tools like 3D printers. The introduction of these technologies may hurt local businesses or the local environment. By empowering the fellows, it is possible that this will only widen the gap between the engineering fellows and other people in the community. To combat these issues, we attempted to approach tools and resources sustainably, sourcing locally where we could, as well as create a roadmap that would lead to third order change using the makerspace as a springboard.

7. Conclusions & Recommendations

While we were initially presented with a suggestion for the solution of the makerspace by our client, we wanted to dive deeper into it and understand the problem. Realizing that the original makerspace was not enough, we came up with the solution of a roadmap to pair with the makerspace. The roadmap serves as an abstract guideline for the makerspace, and a way to understand the makerspace as a continuous project, rather than an immediate design.

The final design that we ended up with incorporates all of our prototypes and research in an initial makerspace design with a roadmap for the future of that space. It includes modular furniture, various workstations, and a rest area. The roadmap includes guidelines for what each iteration of the makerspace should look like, with details on resources and lesson plans that should be provided. We decided not to design the specific lesson plans, as every set of fellows will have different learning desires, so settled on a guideline that all lesson plans Atutu wishes to design for the fellows should follow.

Moving forward, this project needs investor approval, and then the actual dimensions of the space that we would be provided for building this makerspace in. Once we have those things, we would need to follow budget constraints as well as spatial constraints to proceed with makerspace construction. As construction rolls out we would look into smoothing the transition between different points in the roadmap.

Some considerations for the space going forward are the more practical physical elements of the building such as monsoon protection, electrical wiring, accessibility options in the entrance, and safety precautions.

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Appendix

3.2 Visuals

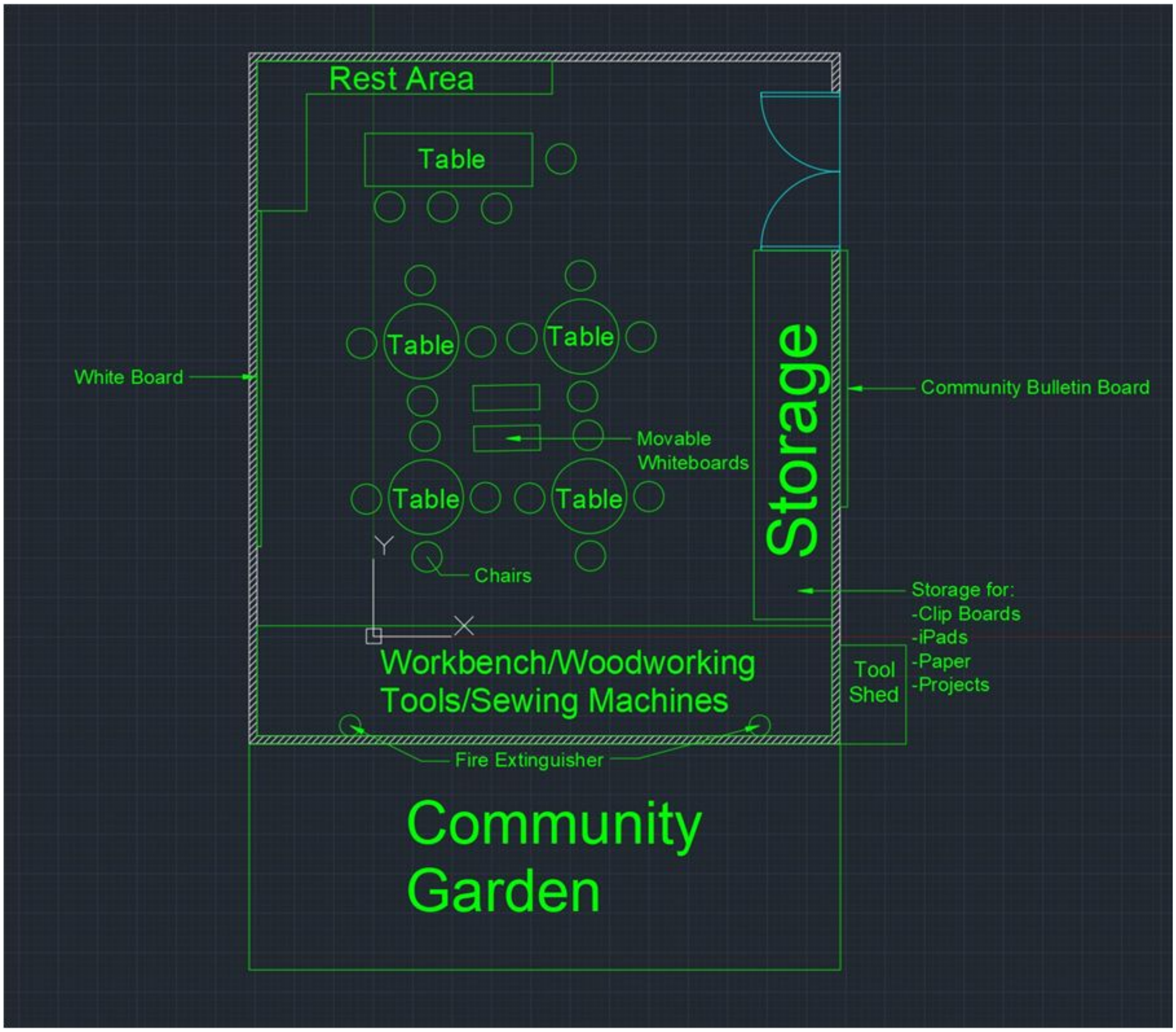


Figure 3.2.1: Community Focused floor plan

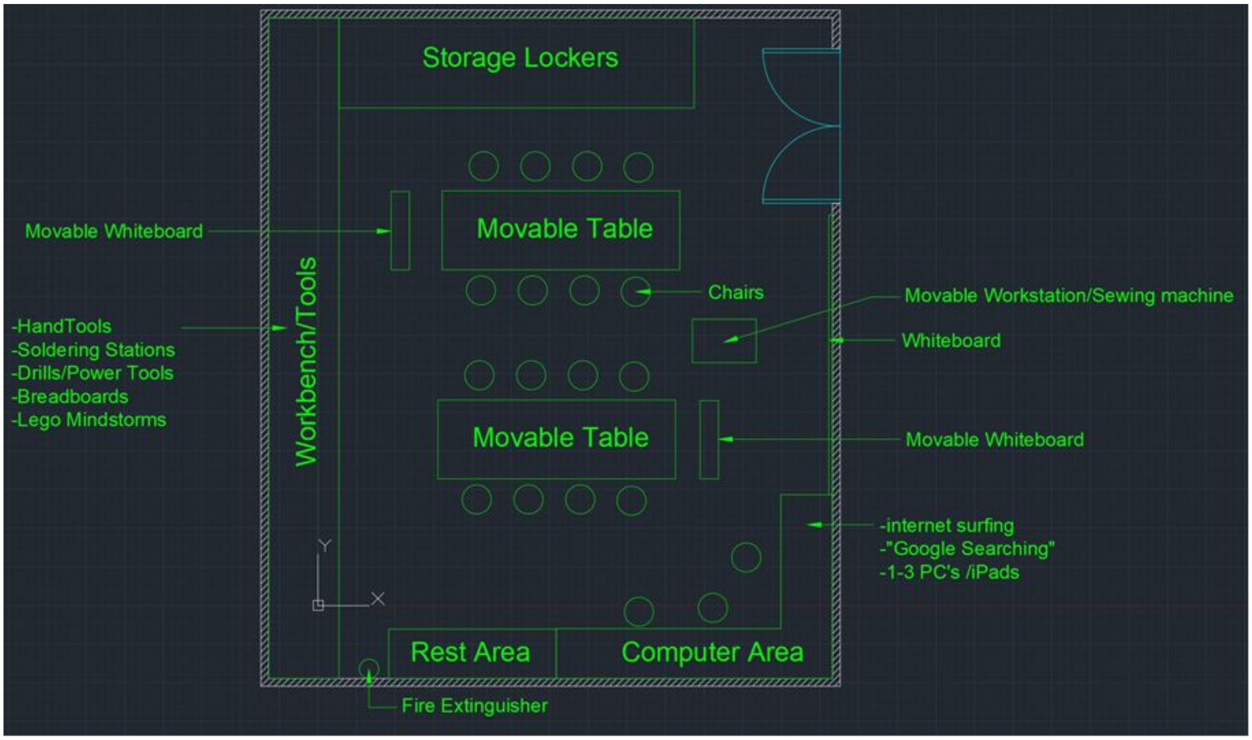


Figure 3.2.2: Innovation/Hobby Focused floor plan

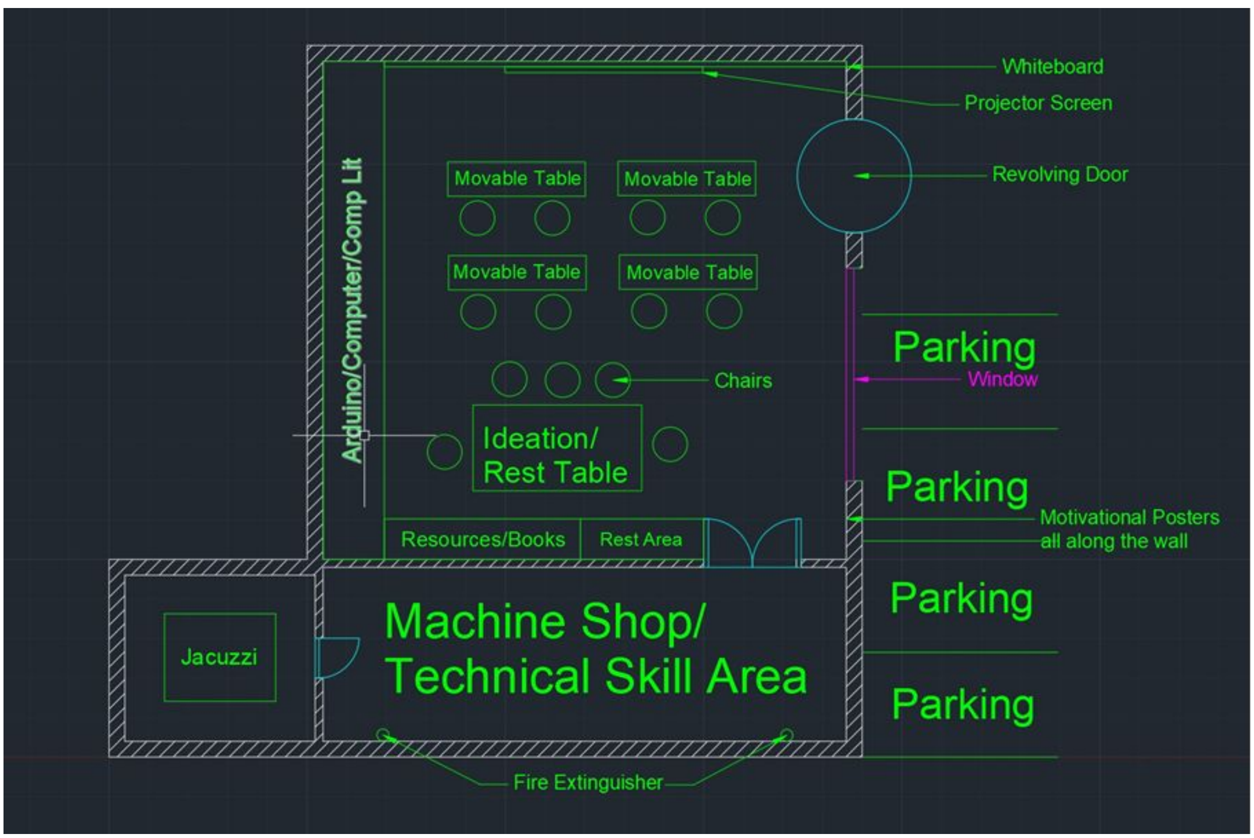
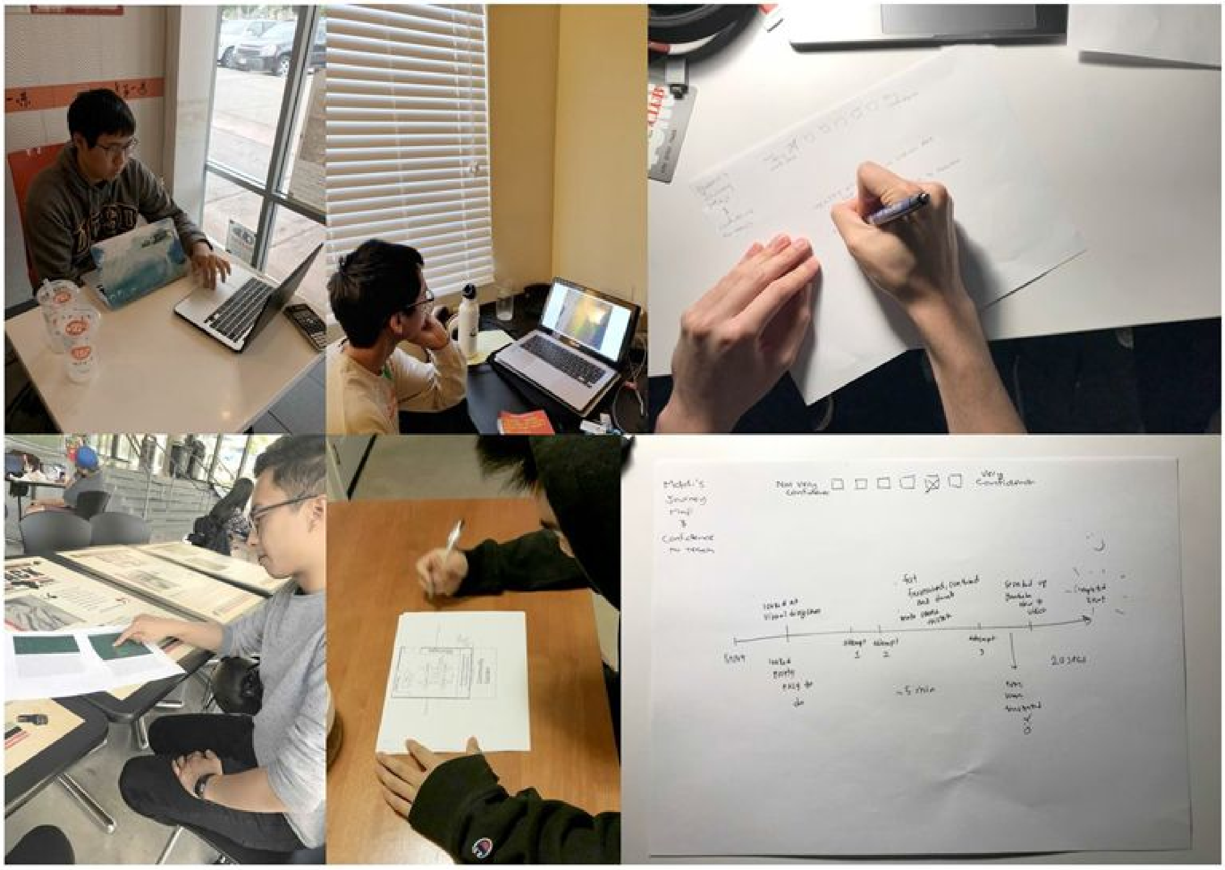


Figure 3.2.3: Professional Development Focused floor plan

Table 4.1 Analysis Summary

Evaluation Criterion	**Metric**	**Target Value**	**Resultant Value**	**Evaluation Method**
Accessibility	Percentage of tools approached	75%	66%	Floor plan simulation with subjects
Longevity	Usefulness of each component of the floorplan on the 10 point scale	80%	53.59%	Floor plan evaluation along with feedback on pros/cons on each component
Sustainability	Confidence Metric, ability to teach others	83.3%	49.83%	User's Journeymap on their knowledge gained
Inclusivity	Inclusivity rating on a 5pt scale	4/5	4/5	Survey
Usability	Ability to follow the instructions without issues	0 questions under 10 minut es	0 questions under 10 minutes	Instruction Manual Testing
Affordability	Cost	<$10,000	$5000 – $10,000	Research



User Testing: Floorplans and Experience through Journey Mapping

Figure 4.2 Desirability and Usability: User Testing

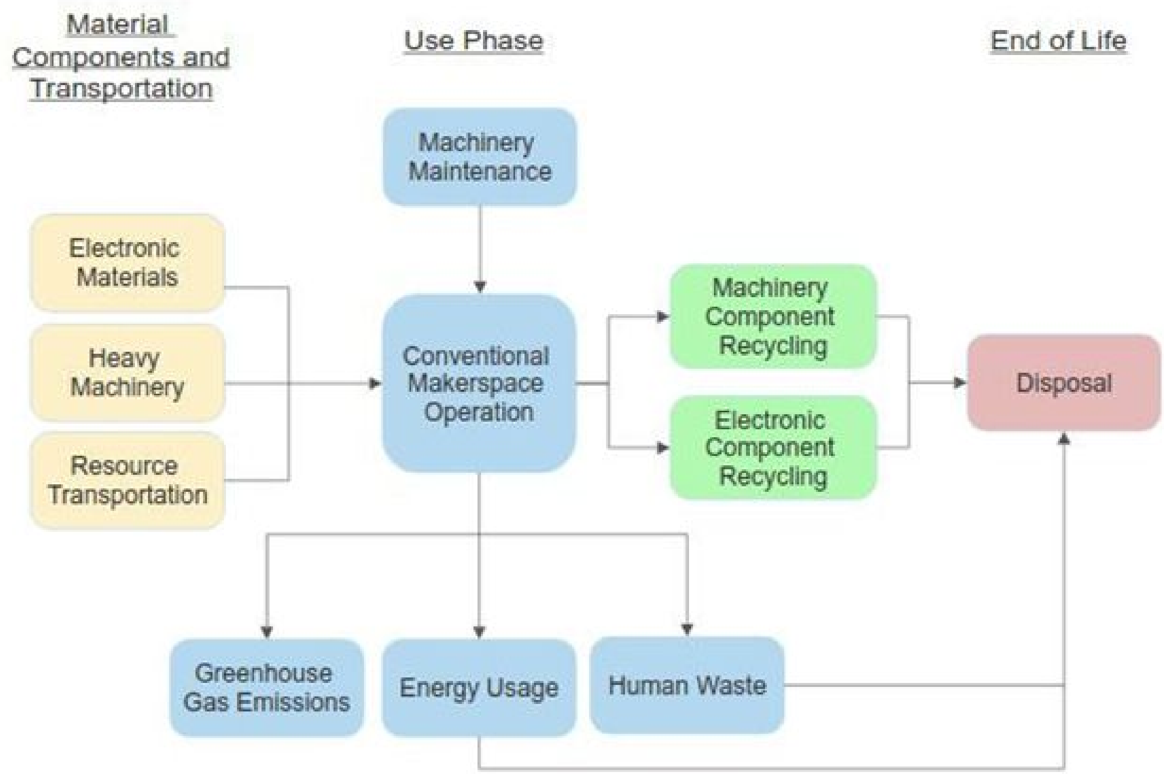
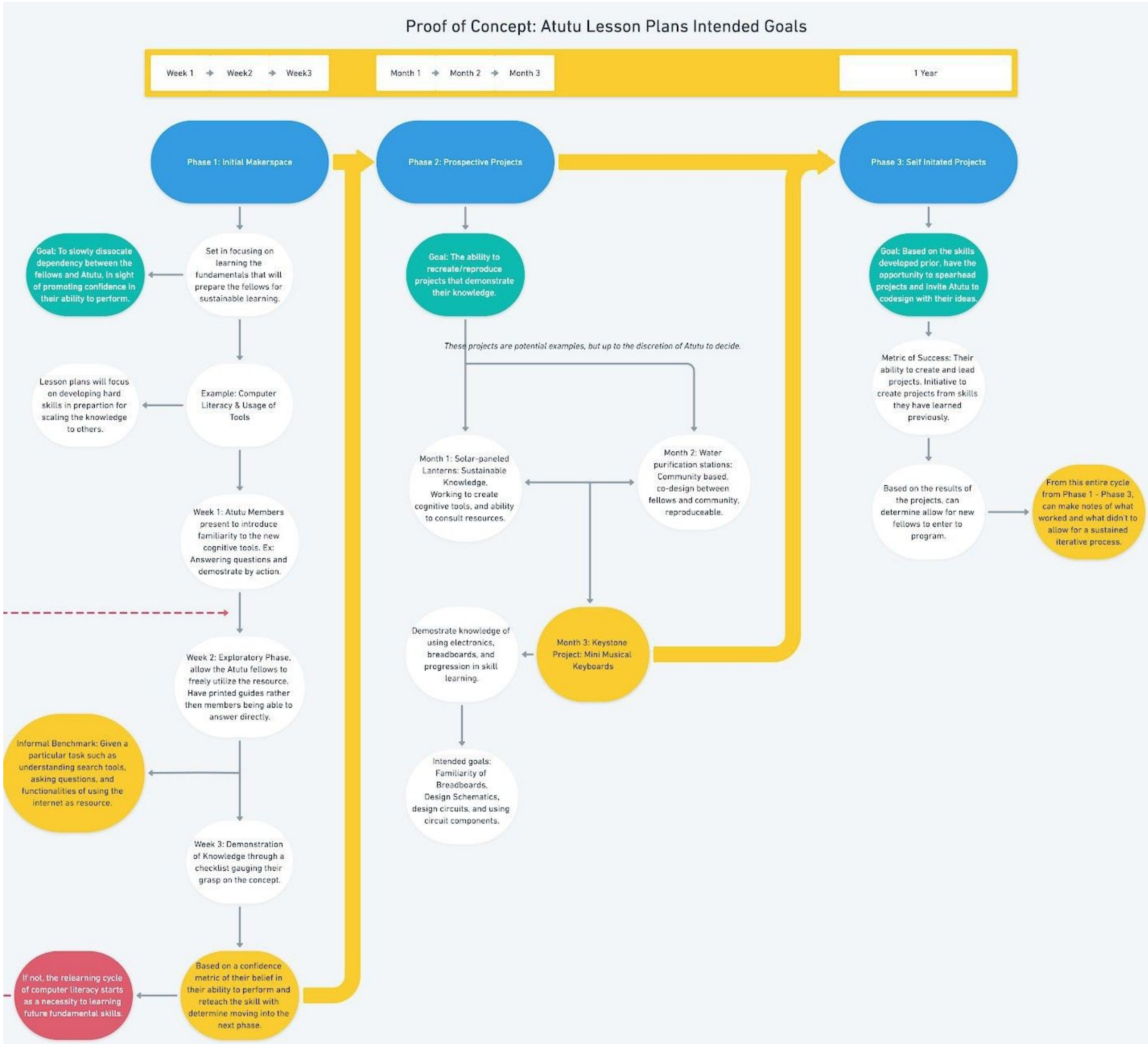


Figure 4.2: Inputs and Outputs of the Makerspace



5.2.6 Proof of Concept: Lesson Plan Roadmap