THE MAKER MOVEMENT

Research report - November 2013

REMY GODZISZ | NATHANIEL HUDSON
KRISTINE VODON | NATHANIEL WILLIAMS
IDES 4310 A - BJARKI HALLGRIMSSON

Contents

Background: A child plays with a DIY pinball machine at a maker faire (Maker Faire Dublin, 2012)

Figures

Left: A child examines a 3D printer at the Oslo Maker Faire (Brynildsen, 2013)

Introduction *About*

This report examines the maker movement, and even more than that, the need for humans to create, explore and learn. All humans have an innate desire to explore, and the Maker Group hopes to develop products that promote the spirit of making.

> We were meant to make things with our hands. It's only natural - it's who we are, and how we tell other people who we are. We are truly privileged to live in a time where the landscape of tradition and technology are merging. This is our generation.
> -Haystakt (2013)

This report seeks to describe the secondary and primary research and early development of four projects surrounding the Maker Movement and Innovative Prototyping. Research centered around four topics: The Maker Movement, Education, Biomimicry and Aquaponic Systems.

The outcomes of this research, in the form of concepts for further development, will also be detailed. Concepts include a physical system for rapidly learning applied programming concepts, a toolkit which allows teachers to easily bring workshop technology into everyday classrooms, a building system that allows for rapid prototyping of objects leveraging natural forms, and a system for experimenting with food production systems combining plants and aquatic animals. Further concepts and schedules for further development will be presented in the appendices of this report.

Introduction
Research Team

The Maker Movement project team is composed of four talented and passionate individuals, each with their own interests in making.

Remy Godzisz

I'm an enthusiastic individual that looks to design for solving real world problems. Merging physical interactions with the digital to create innovative solutions and experiences is an area I am greatly interested in.

Nathaniel Hudson

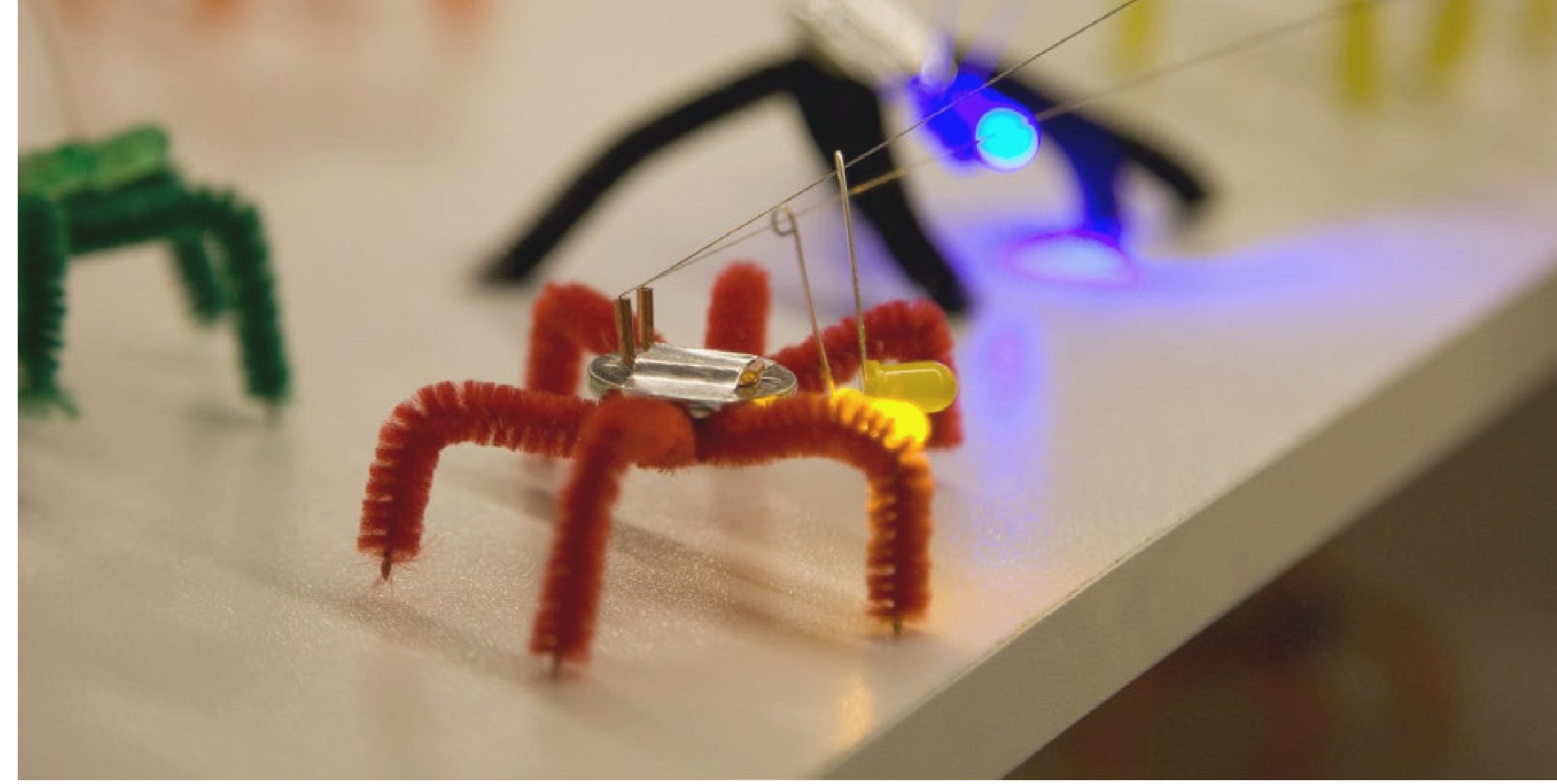
I'm an industrial designer who believes in the future of humanity. I'm passionate about the maker movement, the relationship between physical and digital forms, and bleeding-edge design.

Kristine Vodon

I have a love for art, design and staying active. My minor in Technology, Society and Environmental Studies has allowed me to take a new perspective on my designs. In and outside of the classroom I love building and creating.

Nathaniel Williams

I'm an avid creator and my affinity for exploration has led to a variety of projects ranging from electronics to video to theatrical set design. The challenge of making satisfying experiences drives me to create.



Introduction
Research Methods

Secondary

The Maker Group's secondary research consists of web resources as well as print resources. The general recency of the maker movement, combined with it's highly-connected nature means that web resources are found to be especially pertinent to the work, while print materials are used to back up some of the more theoretical aspects. Resources are located through search engine research, library searches, accessing previously known sources, and through the advice of our primary sources.

Primary

The somewhat amorphous and broad nature of the Maker Movement necessitates significant primary research in order to supplement the secondary research, especially as the research begins to become more specific and focused. This is accomplished by reaching out through the local maker community, by supervisor-provided meetings, and via personal contacts. These meetings take one of several forms. The earliest meetings are informal conversational interviews, allowing the interviewee to share their interests and guide the conversation. In situ observations of Ottawa's Maker community were also conducted, with occasional informal conversational interviews used to gain greater insight on individual projects. Later in the process, when the research became more focused, general guided interviews were used to gain both general information and information that could be compared across several subjects using Force Field Diagrams.

Above:
Simple robots built at the Bay Area Maker faire (Beale, 2008)
Below:
Remy Godzisz conducts an informal interview

Immediate Right:
Makers learn electronics skills at a Maker Faire (Alex, 2013)

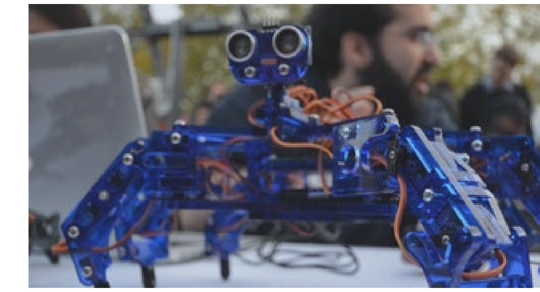
Upper Far Right:
Walking robot on display at a Massachusetts Maker Faire (Wired, 2013)

Center Far Right:
An open-source chair built from unwanted palettes. (Instructables, 2013)

Bottom Far Right:
The Sashimi Tabernacle Choir, a car covered in singing fish (MMN, 2013)

The Maker Philosophy:

- If it can be imagined it can be made.
- Collaborating with others results in greater creativity.
- Making things always combines form with function.
- The art of making should be appreciated and celebrated.



The Maker Movement
Secondary Research

Fueled by advances in communications, electronics and manufacturing, THE MAKER MOVEMENT exists to build and share. A community with an emphasis on collaboration and exploration, the maker movement serves as a 21st century update to one of humanity's most essential aspects: the urge to create.

The maker movement is here. Creating useful, innovative or beautiful things either in their homes or in collaborative workshops known as makerspaces, makers seek to learn and explore by building (Giridharadas, 2011). After a project is completed it is often displayed online or at a maker faire (a maker community event where projects are displayed) for others to learn from or be inspired by (Bjerede, 2011).

Collaboration plays a very central role in maker culture. The community has embraced concepts such as open-source, where rather than just displaying the final results of a project, the plans and instructions are shared, allowing others to build their own or improve upon a design. This is often accomplished through the internet on sites such as instructables, or in person at workshops or maker faire events such as the one seen in the image above.

What do Makers Make?

The projects taken on by makers are startling in their diversity. Pictured here is a robotics project, a woodworking project, and a project that is difficult to classify. While there is no such thing as a "normal" maker project, projects frequently strive to embrace both engineering and artistic challenge, often combining a range of mediums (Cole, 2011).

The Maker Movement
Primary Research - ModLab

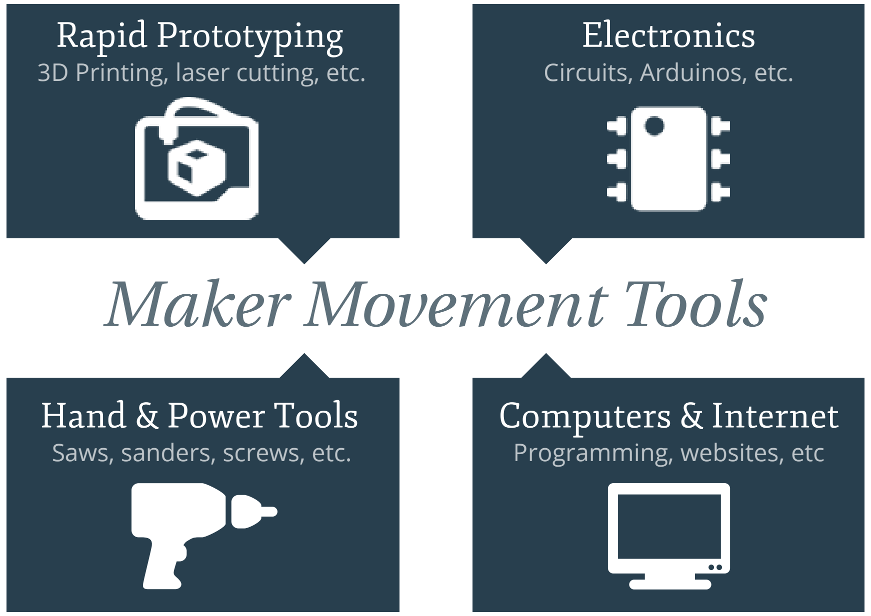
In-situ observations and informal conversational interviews were conducted with Ottawa's hackerspace, ModLab, which is run by ArtEngine, a group dedicated to works combining art and technology (ArtEngine, n.d.). The space takes the form of a pair of rooms within Ottawa's Art Court, equipped with soldering tools, a small number of simple hand tools, a pair of 3D printers and a laser cutter. ModLab's administrator states that while she would like to acquire machine tools, they are limited by the size of the space, and other logistics factors.

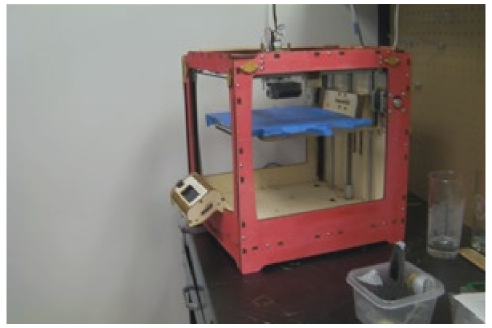
The people observed came from primarily engineering and technical backgrounds. Observation and conversation revealed a wide range of projects underway, ranging from AI development to 3d printers to high-speed photography to lighting to undirected experimentation. Members were eager to discuss their projects and would often ask each other questions when they hit a problem. Attending this meeting was valuable as it provided first-hand experience into the hackerspace workstyle and environment.

Above: ArtEngine ModLab's main meeting space, showing soldering equipment, 3D printers and working makers.

Maker Tools

The modern maker movement is marked by a massive increase in the complexity of projects (Giridharadas, 2011). Hand tools and Digital tools have become accessible and affordable, freeing the boundaries that restrict a maker's imagination. The internet enables self-driven learning and community collaboration, exponentially multiplying makers' collective imagination. Whether employing a bandsaw, 3D printer, soldering iron, or keyboard, makers adapt their multidisciplinary knowledge of tools to achieve a given end (Cole, 2011).





Above: Tools available at the modlab space, including soldering and 3D printing stations

The Maker Movement
Primary Research - Interviews

The group met with Luc Lalande, one of the directors of ArtEngine, and Anthony Dewar, a graduate student researching 3D printing, to discuss the insight they have gained from being closely involved with the maker community. Both were keen on the tendency of makers working in close proximity to cross-pollinate. Luc was a proponent of the transition from the traditional STEM education to include arts and form STEAM, as a more comprehensive approach. Luc also emphasized the importance of active instead of passive engagement in education: rather than a traditional education an instructor vocally imparts knowledge to passively receiving students, Luc advocates a hands-on approach where students learn in action.

Above: 5th grade students engaged in a STEAM learning exercise design and program robots at Woodland Elementary School. (Marzouk, 2013)

Education & Learning
Secondary Research

Education is a key subject as it is so closely intertwined with prototyping and the maker community. We use prototyping as a method of education, to work through iterative testing and improvement to understand faults and refine a design.

There is a crisis in education. A startling number of students are missing key educational foundation, leading to unemployment. Within Canadian schools, over 30% of students are in need of extra educational support to reach basic competency levels (Rogers Youth Fund, 2013). Furthermore, students are increasingly detached, with 40,000 students dropping out of high school every year (Rogers Youth Fund, 2013).

Problems arise not only in student dropouts but also from the curriculums being taught in schools. Math scores have been in the decline throughout Canada, leaving the curriculum under scrutiny. A major disconnect between the math taught in schools and what is seen in post-secondary and work world leaves students detached and apathetic (Wente, 2013). Currently there is a push to transform STEM (science, technology, engineering, math) into STEAM, including arts and design. Proponents say that the arts and design drive innovation, which will transform the economy of the future (STEM to STEAM, 2013).

> There is a push to transform the traditional STEM curriculum into STEAM, including the arts and design.

Self-directed learning is alternative approach to strict school curriculums, where an individual learns through experimentation. Students take initiative to determine their direction, needs, and goals (Alternatives to Schools, 2013). There are many positive attributes that come from self-directed learning including natural development of self-confidence, initiative and self-satisfaction (Alternatives to Schools, 2013).

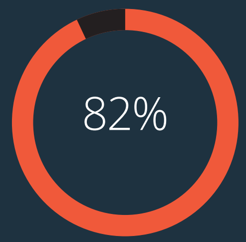
Above: The inside of the SparkTruck, showing a wide range of tools (SparkTruck, 2012).

Educational Initiatives: The SparkTruck

The SparkTruck is a roaming makerspace developed by Stanford University as a way to bring hands-on learning to students across the United States. The SparkTruck is a retrofitted truck outfitted with 3D printers, a laser cutter and traditional tools which travels to schools to conduct educational workshops where students learn by making (SparkTruck, 2012).

Current curriculum drives students away from STEM:

60% of students beginning high school who express an interest in STEM disciplines lose that interest by the time they graduate high school (Liu, 2013).



A desire for more creativity:

A survey from Adobe on creativity and education states that 82% of parents wish that their children had more creative thinking in their education (RISD Office of Government Relations, 2010).

Education *Primary Research*

Four educators were interviewed using general guided interviews in order to establish data that could be compared and contrasted, as well as to obtain more general opinions and interests.

Brent Smith, the principal of Putman Public School and a proponent of student-driven learning in school, has opened a maker space at his school where students are provided with resources to work on a variety of non-curricular projects. Dr. Georgina Purchase is an elementary teacher at Jack Donahue Public School runs a club where students independently learn about and build small racing solar cars, and has her students engage in hands-on construction as part of her regular science and math classes. However, due to the way elementary school curriculums are structured, she is limited to 40 minutes of time using the workshop facilities, and only when there are no scheduling conflicts. Stephen Emmell is a high school computer science and math teacher at West Carleton Secondary School. His grade 12 computer science class is extremely self-directed, with students setting their own goals, timelines and deliverables. Doug Commons is a retired electrical engineer who is working with Glen Carin Public School in order to provide a hackerspace and maker technology for the students to use.

The table below organizes the reasons interviewed educators felt driven to pursue the innovative programs that they did, as well as the forces or perceived forces that held them back.

	Driving Forces	Restraining Forces
Brent Smith Primary School Principal	• Enables student's desire to play • Enables teacher's desire to see students innovate • Teaches value of mistakes and iteration	• Teachers unable to see how it fits into the curriculum • Teachers intimidated by lack of familiarity with tools or subject • Limitations of classroom space
Dr. Georgina Purchase Primary School Teacher	• Adds authenticity to lessons, helping hold student's attention. • Provides students with new experiences • Teaches value of mistakes and iteration • Inspires confidence	• Safety and Financial factors • Limitations of school facilities, such as schools without shop facilities • Teachers intimidated by lack of familiarity with tools or subject • Students intimidated by tools
Stephen Emmell High School Teacher	• Allows students to self-set standards • Allows for more "real world" interactions	• Difficulty with predictability of tools • Pushback from students unsure of how to learn independently
Doug Commons Maker and Education Volunteer	• Enables students to experiment with new technology • Teaches value of mistakes and iteration • Keeps kids engaged for longer periods of time	• Difficulty teaching across skill levels • Difficulty teaching to different interests • Difficulty managing large groups

Background from (Southfield Institute, 2013)

Programming & Code

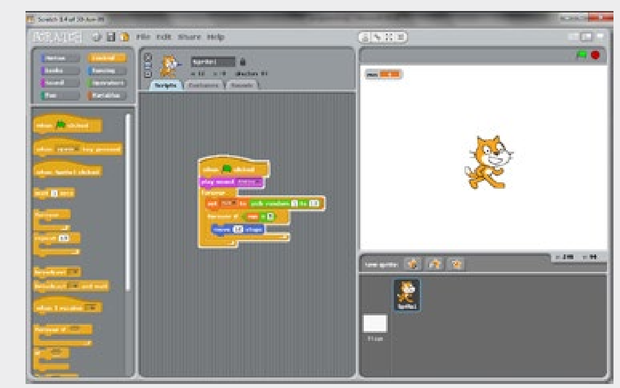
Secondary Research

The most basic explanation of programming is telling a computer what to do. A computer uses switches that may be turned on and off as a foundation to run and make decisions. Complex combinations of commands being turned on and off allow pieces of hardware to communicate and with each other and the user via the screen.

The language of computer is called binary or machine language. Now for us to program in binary would be extremely time consuming and inefficient so we use programming languages to translate (Microsoft, 2008). These languages are much easier to understand and work with for the programmer.

There are many different programming languages such as Java, C, C++, Python, Turing, Scratch and PHP. Different programming languages may be better suited for different applications and tasks (Rothberg, 2006). Most of these do require a large investment of time to learn as they are complex and sometimes overwhelming. To engage younger audiences and eliminate complexity, programs such as Scratch are used to teach the basics.

It is becoming more important for kids in school to start learning these skills in school. As we are in the digital age, education systems still lag behind and children are leaving school ill-prepared for the modern, technological work market. It is said that currently less than one fifth of children are considering entering a field within STEM (La Fleche, 2013).



Right:
Scratch, an programming environment for children learning code basics

Primary Research

The research team visited Artengine's ModLab and talked to a couple makers who are programmers, providing some insight on the topic. Wessely is a Mod Lab regular who works for Shopify and Mohammed an engineering student who programs on the side. To get some general understanding they broke down programming into three broad categories, including control structures, operations and variables, which can then be further broken down. Also discussed were common errors that arise in programming. One problem mentioned was the complexity of systems and staying on top of all components working together. The bigger the program, the more components are working together to create the whole. Another issue that arose is debugging; the process of finding and fixing errors within the program.

Variables/Constants

Integer
String
Boolean
Character
Float
Array

Operations

+
-
x
/
=
sin
cos
tan
sq
sqrt
random

Control Systems

When
Loop
If
While
Goto
For Each

Common Errors

Managing Complexity

Off-by-one Errors

Syntax Errors

Debugging

Undeclared Variables

Radiolaria structures are unique micro skeletons made up of silica in a crystallized form. Their organized structure increases the strength of the single-celled organism.

Biomimicry & Design
Secondary Research

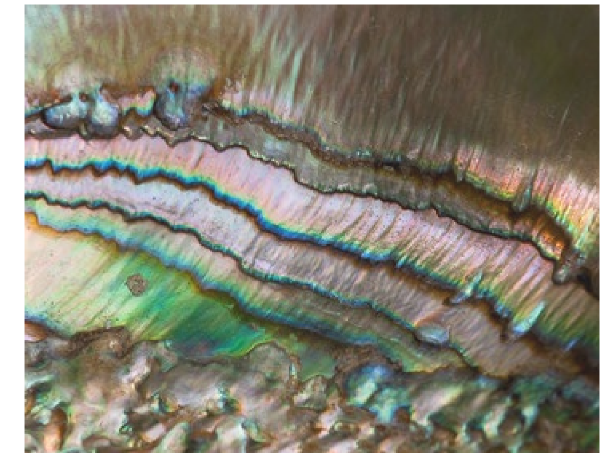
Researching biomimicry has led to a deeper understanding of its applications and how it has the potential to benefit the maker movement by augmenting the advantages of 3D printing.

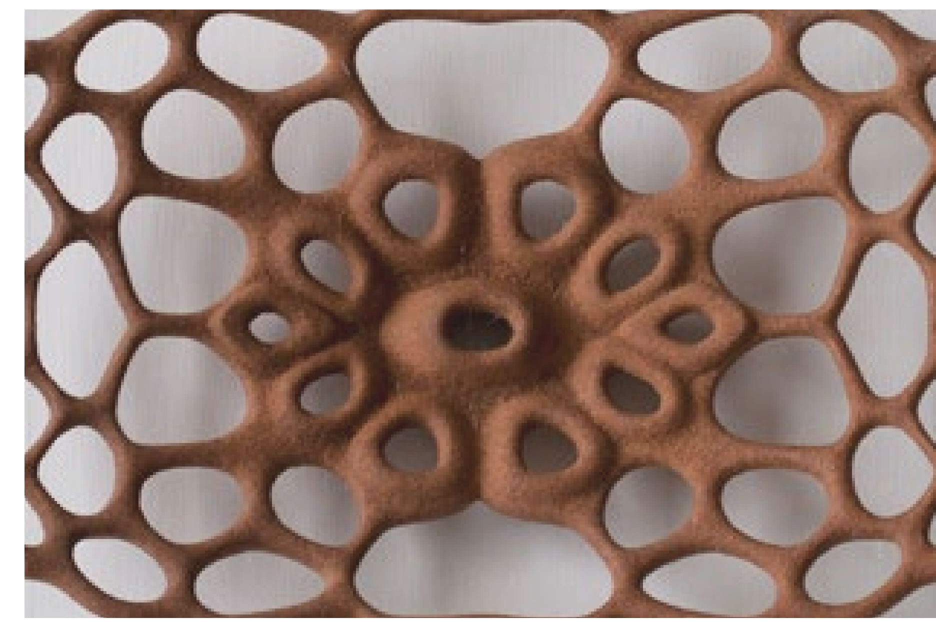
Biomimicry is a new, and rapidly growing field that adapts inspiration from nature and applies it to human made forms, processes, and systems. (Banyus, 2013). Research within this field for this project has been focused on materials and forms that contribute to high strength and low material use.

Currently, biomimicry is being applied mostly at the professional level within high end architecture firms, such as Perkins+Will Architecture firm, (Perkins+Will, 2013) and specialized companies like Sharklet (Sharklet, 2013) which applies shark skin technology to consumer products. Biomimicry is not accessible to the average 'maker' but it could have a huge ecological impact if everyone took into account how to work with nature to learn from it, instead of against it.

Most primary research has been looking at inspirational shapes and joints that can be useful within prototyping for a user in the maker movement. Research on materials hopes to bring forth the sustainable processes that mimic the way nature recycles its materials in a closed-loop system. By changing materials not only will there be a benefit for the environment, but there would also be benefits for the user. An example is the abalone shell that is stronger than high-tech ceramics because of the way the shells are build up silica with stress-distributing patterns. (Haward, 2013). Companies like Emerging Objects are developing processes to utilize more natural materials such as wood and recycled newsprint which helps work towards a closed loop system as proposed by Janine Banyus. (Emerging Objects, 2013) With well developed, beautiful structures bring forth form, and materials allowing for greater efficiency and use this application of biomimicry links form to function for a balanced product that will attract many. Inspiration for form development had been taken from radiolaria and the structure of other human scale skeleton systems. The radiolaria are unique as single-celled organisms that self-assemble into unique larger structures that optimize their energy use, polymer use, and strength. These structures have fascinated researchers and are beginning to be applied within modern architecture and design. (UCMP, n.d.)

> "One big problem with 3-D printing in its current form" says Benyus, "is that many of the printers rely on toxic building materials"





Far Left:
Diversity of Radiolarian From (UCMP n.d.)

Left:
Tough structure of the abalone shell (Howard, 2013)

Bottom:
3D printing process that uses wood fibres (EmergingObjects, 2013)

Aquaponics
Secondary Research

Aquaponics is the merger of hydroponics (growing plants in water) and aquaculture (growing fish in water). It is based on the principle of balancing fish, plants, and bacteria to thrive in a controlled aquatic ecosystem.

Biophilia

Prominent naturalist Edward O. Wilson states, “The phenomenon has been called biophilia, defined as the innate tendency to focus upon life and lifelike forms, and in some instances, to affiliated with them emotionally.” (Wilson, 2002) This is particularly evident in the environments we create for ourselves.

Human + Nature Relationship

Humans are inherently attracted to nature because our species evolved in the wild for millions of years. In the past several thousand years, we have developed elaborate structures in which to live, and have been decorating them with nature from the start. Potted plants are frequently grown in living rooms throughout the globe, and fish tanks or aquariums are often displayed as focal points of an interior space. This affinity for life has been confirmed as effective stress relief in a medical context: Hospitals have calculated the costs and benefits of maintaining gardens on-site for patients to visit, and simply viewing a garden has such a dramatic effect on the human psyche that patients heal faster (Marcus, 1995). Bringing pleasure to the senses with plants is extremely effective stress relief. Hospital patients noted that seeing leaves flutter in the wind was especially pleasurable.

The majority of aquaponic systems are applied either to grow food, or create an aesthetic display. Household aquariums (aesthetic displays) are often modified into aquaponic ecosystems to ease cleaning, and sometimes to grow food.

The science behind aquaponics is simple: it’s a small scale reproduction of the ecosystem cycles that enable life on a global scale. The main nutrient cycle exists between fish, plants and bacteria. Fish waste is toxic to plants, but bacteria thrive by breaking down the ammonia waste into nitrites and then nitrates. These nitrates act as fertilizer to the plants, effectively translating waste into food (McDonough, 2002).

Aquariums are a popular way to bring the outdoors inside, whether it be at the scale of a museum or a bedroom. Big Al’s Aquarium shop in Ottawa sells a variety of equipment and wildlife, with most home tanks ranging from 5-50 gallons. On the small end of this spectrum, there has been a recent rise in the popularity of ‘nano’ aquariums that range from 2-5 gallons and provide an all-in-one solution for simple setup and maintenance. A sales associate mentioned that such nano-aquariums are popular with apartment dwellers who “just want a fish.”

User interaction with an aquarium

DIY Aquaponics (Keeler, 2013)

‘Riparium’ Swamp Tank (Biggs, 2011)

Professional ‘Aquascape’ (Amano, 2009)

is defined by maintaining the water quality and filter, and enjoying the vibrant result of one’s effort. Most aquariums are designed for visual appeal- creating a “scene” underwater and populating it with a variety of novel organisms. Fish and plants are chosen for their bright colors and eccentric shapes. Pumps, fans, and filters (bacteria cultures) are hidden away from view so that the viewers focus is on the “scene” (McClung, 2012).

Aquaponic systems expand on aquariums to include terrestrial plants, grown in the aquarium water. This essentially ties potted plants into the aquarium system, unifying the two prominent forms of biological decoration. The user now builds relationships between plants and animals instead of isolating them in different locations.

Aquafarm is a tiny aquaponics system recently launched from a kickstarter campaign. The $60 system condenses an ecosystem to the counter-top scale for easily growing herbs with a beta fish at home. Growing plants to eat adds another level of interaction with the system, a tangible outcome for the farmer’s enjoyment (Back to the Roots, 2013).

Ecosystems are nearly infinite in the range of organisms- from simple arrangements like aquafarm to complex arrangements like garden pool, which incorporates insects, chickens, and worms into the nutrient cycle. This biodiversity is flexible to personal interests and needs, and will gladly adapt to change should the user decide to grow their ecosystem (McClung, 2012).

Interactions like eating food, smelling fresh flowers, and raising a school of fish are direct tangible and pleasurable outcomes that engage humans on a primal level.

Garden Pool:

This large-scale aquaponic greenhouse is designed for food production, cleverly framed in a repurposed swimming pool.

(McClung, 2012)

Aquafarm:

A recently introduced counter-top system, the Aquafarm is an all-in-one product that houses a beta fish and grows herbs for cooking.

(Back to the Roots, 2013)

BitPonics

Bitponics is a hydroponic monitoring system that tracks water temp, pH, sun exposure, etc. and communicates them as infographics through an app.

(BitPonics, 2013)

Aquaponics *Primary Research*

Alëna Iouguina

Masters Student studying bioinspira-tion in design at Carleton University

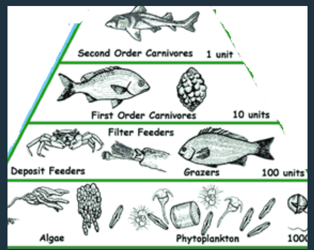
On Aquaponics:

Although Alëna doesn't focus on aquaponics specifically, her background in biomimicry involves translating the systems of nature to design applications. She brought up the passive manner in which many natural systems function as a basis for framing a constructed ecosystem. Taking advantage of these passive tendencies can produce a more stable system that relies less on electrical input such as pumps, fans, or heaters.

Alëna also sees the value of such systems in an educational setting, as a tool for enabling bioinspira-tion directly in a workspace instead of as a separate experience outside.

Dr. Jeff Dawson

Associate Professor of Biology at Carleton University



Trophic Levels
(Johnson 2013)


Arduino Microcontroller
(Arduino 2013)

On Aquaponics:

Dr. Jeff Dawson's background gives him a perspective rooted in the natural cycles framed in an aquaponic system. Jeff brought up the concept of trophic interactions within an ecosystem, and how dividing up the components will functionally alter relationships between organisms. For example, both aggressive and docile fish can be raised if isolated in a multi-cell system.

Jeff also has a background in arduino programming and was excited by the prospect of employing a range of electronic sensors to collect data and provide long term perspective on key variables affecting an ecosystems health such as air / water temperature, water PH, and sun exposure. This in-formation empowers the user to track and optimize growing conditions.

Through discussing the balance of complexity in building a healthy ecosystem, it became apparent that a well-paced process of construction is essential for a successful project. Com-municating the process of construc-tion is especially pertinent if a system is intended to reach beyond special-ists to novice aquarium keepers.

Jeff's PhD student Ryan is an advanced aquarium enthusiast who grows coral in saltwater tanks, and he mentioned a number of aquarium companies that produce systems of advanced sensors. Ryan sees opportunity in reproducing local biomes in an aquarium setting, drawing organisms from the local en-vironment to create an ecological-ly correct micro-system. He noted that aquarium owners are often disengaged from the biology of an ecosystem and "90% of people just want a fish."

Biomimicry *Primary Research*

On Biomimicry:

Multiple conversations with Alëna have been very valuable especially in the early research phases of this project. Her ability to provide many examples of relevant work in her field has helped build a clear picture of how biomimicry can be applied, and the different levels of benefits it can apply.

Alëna has provided books and research papers to provide an academic foundation on biomimicry, as well as providing the names of contacts for further interviews. Her passion on the subject is motivating and her knowledge helps when diving into such a new and vast field.

Alëna was the first to bring forth the concept that nature most often uses less material to create stronger performing structures. This was the spark that ignited the idea for a bio-inspired prototyping system.

On Biomimicry:

Jeff Dawson has been very influential on the development of the final idea for a product to combine rapid prototyp-ing and biomimicry. Jeff is the perfect contact as he identifies with the maker movement, he is extremely knowledg-able on the subject of biology and he uses rapid prototyping for his research.


Dog skull showing the jawbone joint

Dr. Dawson believes that 3D printing is a great way to reproduce natural and complex forms. He mostly uses this advantage as a research aid within biology, but the application also runs deep into the core of this project.

Looking at jaws and other bone joints, has helped move this project in a feasible direction. Dawson's interest in design has brought forth collabor-ative ideas that truly bring the field of biology and design together.

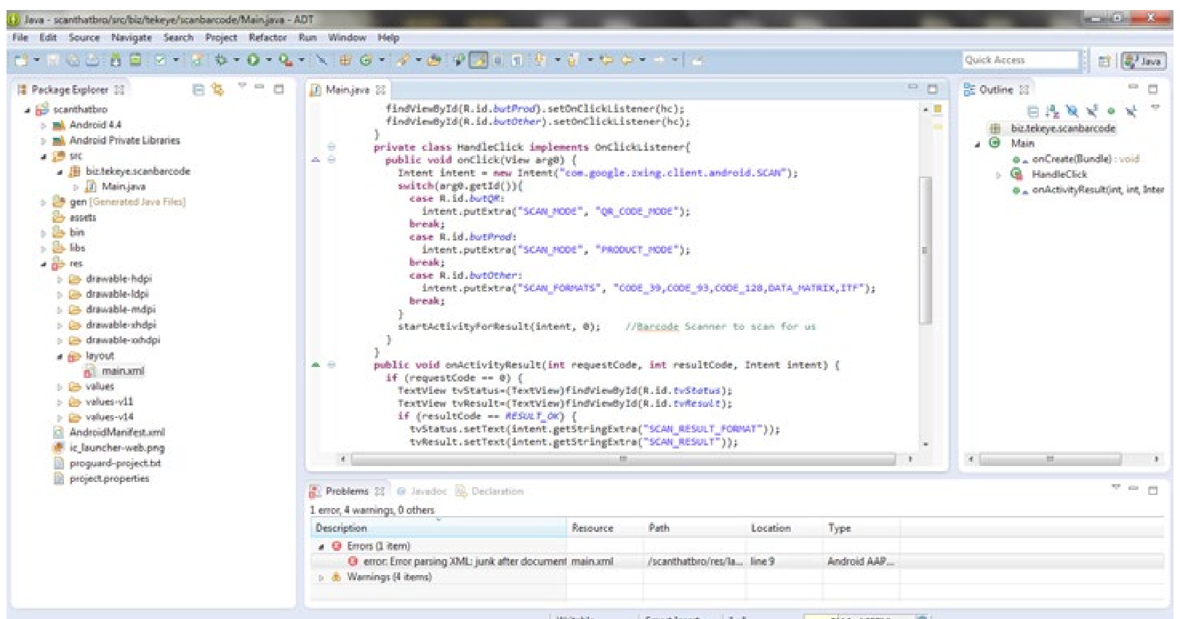
Material efficiency and modularity are two criteria of the project that Dr. Dawson has been able to discuss at length and give examples of solutions that are commonly used in nature. His research on flight has been useful in looking at the linking mechanism used between insect wings and how it can be applied as a hinge system. Discussing the structural form of bones has shown exactly how the structures work to use less material to determine which way the bone can take a load bearing.

As a co-supervisor on Peter Wehrs-pann's Industrial Design Master Thesis Project in 2011 Jeff has been able to give information on the benefits of applying biomimicry and how it can greatly impact the design process when it is used as an inspirational tool.

Results: Concept

Remy Godzisz

Based on my primary and secondary research, I have chosen to pursue the concept of creating an educational prototyping tool for learning programming. It will look to bring physical interaction to the process of computer programming, creating an innovative, educational experience for the user.



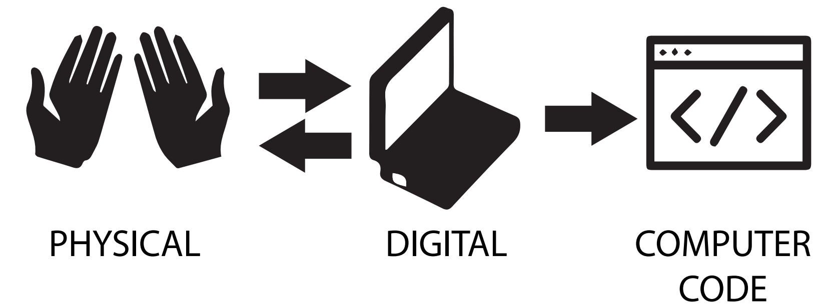
Left:
Coding in Java using the Eclipse development environment

The main issue is that computer programming is a very complex task and takes a large investment of time to become fluent in. It is also a process that involves little physical engagement apart from typing. These issues can be very intimidating and create knowledge road blocks for people to begin programming.

I would like to create an educational prototyping tool that helps students learn and understand the concept and process of computer programming. This will be done through incorporating greater physical interaction to create a more engaging and educational experience.

My concept is to develop a system that utilizes physical 'building blocks' or cards that integrate with each other and digital devices. These blocks represent different computer programming control systems, operations and variables, allowing the user to build a computer program out of physical pieces opposed to purely onscreen. These blocks can integrate with digital tools such as a camera scanner to bridge between the physical and digital world.

As a result of using digital hardware such as scanners, the user is able to build with the physical blocks while maintaining a link to the digital side. This two-way dialogue opens a lot of doors with integrating components and further development.



From my research I have found some of the common errors that arise in programming, such as complexity of systems and syntax errors. I would like to make sure my concept addresses these issues. The building blocks that I plan to incorporate will not require the user to write out complex syntax and structures, but instead focus on understanding the underlying concepts the code conveys.

I am currently in the process of prototyping and clarifying different methods to carry out my concept. The major aspect I am currently looking at is finding what parts best work as digital and physical. Whether the building blocks actually contain electronics or instead blocks that interact with a digital device is still being looked at.

So far I have been testing QR codes on cards with no electronics inside, using a camera to read them. I am exploring the idea of using a projector / scanner to read and interact with configurations of many cards on the table. Both the projector and scanner would be in one electronic device as seen in the picture on the top left. The camera scans the cards creating an input where they can be processed digitally. The projector is then able to visualize output data back onto the table offering realtime feedback and interaction.

Using a projector to offer visual output data allows for instant feedback. For example if cards are placed in a nonlogical way, the device could recognize that and project an error message to what is wrong and potentially a solution. Creating different modes via software for the system could allow for gamification and testing for the user. For example a gameboard could be projected onto the table where the user plays with the programming cards. Something like this could make for a more enjoyable experience for a student and less of a chore to learn.

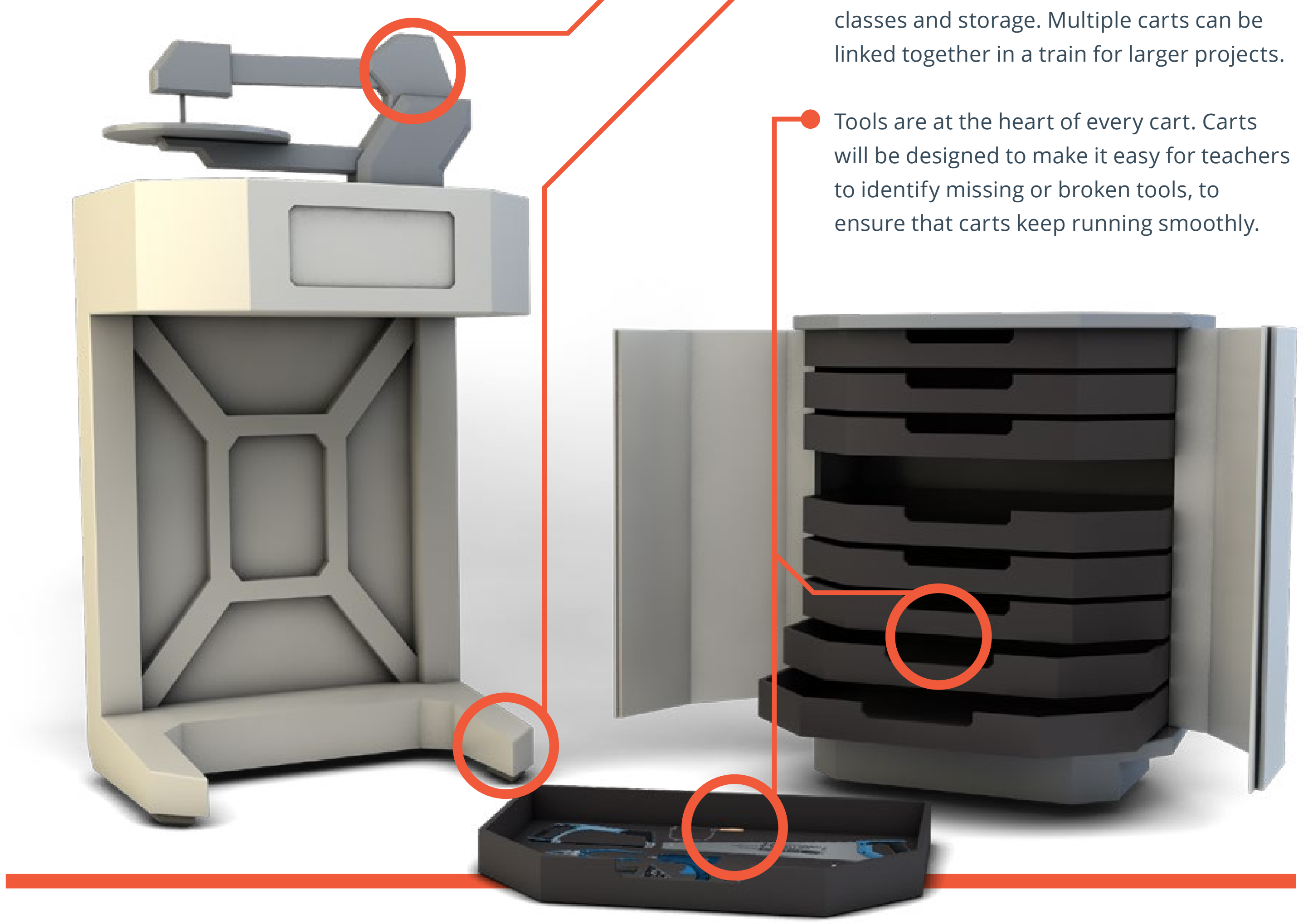
Further exploration is currently taking place, looking into building blocks for the system that contain electronics within them.

Outcomes: Concept

Nathaniel Hudson

Lack or overbooking of available workshop facilities is a major obstacle to the adoption of learning by making in schools. Rather than bringing students to the workshop, I believe that there is an opportunity for a product that brings the workshop to the students: a mobile tool cart which can bring making into any class.

- Every cart mounts a single large tool to maximize the number of projects the cart can help with. How the tool is used is up to the teacher - set it to instructor-use only, or let more advanced students use it on their own.
- Since time is at such a premium in elementary schools, carts are mounted on wheels for easy transportation between classes and storage. Multiple carts can be linked together in a train for larger projects.
- Tools are at the heart of every cart. Carts will be designed to make it easy for teachers to identify missing or broken tools, to ensure that carts keep running smoothly.



Different projects, different carts:

The system is modular, allowing teachers and schools to choose which carts best work with their curriculum and students.

Woodworking I

Contains tools such as coping saws, hammers, screwdrivers and glue guns. Mounts an integrated scroll saw. Focus on arts or geometry classes, or introduction to tools.

Woodworking II

Contains tools such as power drills, hand saws, palm sanders. Mounts an integrated band saw. Focus on science and technology classes, or classes with tool experience.

Support

Contains goggles, work surfaces, clamps. Focus on supporting other carts with safety objects and amenities.

Electronics

Contains tools such as soldering irons, voltmeters and ammeters. Mounts an integrated reflow oven. Focus on arts, science and technology classes.

Advanced

Contains integrated laser cutter and 3D printer, as well as control systems and supplies. Focus on arts, science and technology classes interested in computer-driven tools.

Outcomes: Concept
Kristine Vodon

After talking to experts, reading articles and books on the topic of biomimicry, and talking to potential users in the maker movement I have developed an idea to bridge the gap between maker movement and biomimicry as well as creating a new tool that will break through barriers to 3D printing.
It will be a Bio-Inspired prototyping system.

The research so far has lead to the idea of making a new prototyping system that breaks through the barriers to 3D printing as a prototyping method and also brings forth biological inspiration through joints and forms.

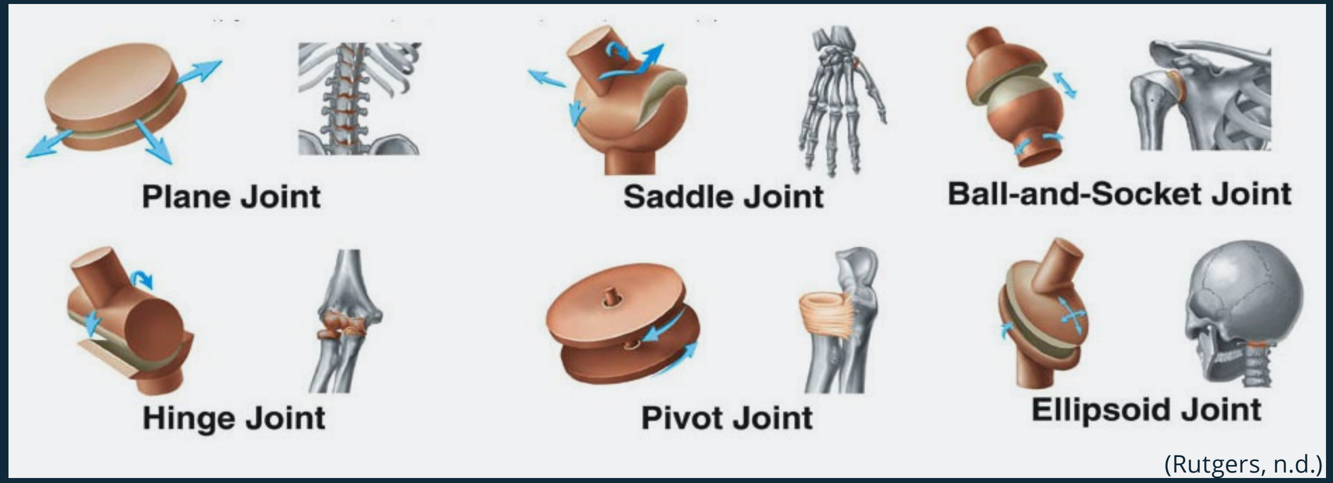
The system would be composed of elegantly formed, modular pieces that can be built upon one another, yet each part would also be transformable in the way it links to the next. The joints and form of the pieces would all be designed through the application of biomimicry so that they are strong, lightweight, material efficient and aesthetically appealing. By 3D printing these parts the material waste will greatly decrease because of the additive process it uses.

As a new system it can be used for rapid prototyping (as an iterative step in any 'makers' design process) or it can be directly used as a final product as a rapid manufacturing tool. The projects that are built with this system can be directly used within the home as a finished product that is completely up to the users design and needs. Since the process is much more loose and free than using complicated Computer Aided Design Programs, it will support creative flow of building and tweaking things with your hands. With parts that can be easily manipulated, or completely rebuilt after printing I will be able to transform 3D printed objects from a static form to an adjustable, creative form. Ideally, this will make the tool of 3D printing more widely accepted by the target users - the maker community - and thus bring forth a process with less waste, biological inspiration, and creative possibilities.

Concept Variations
for further testing

Joints

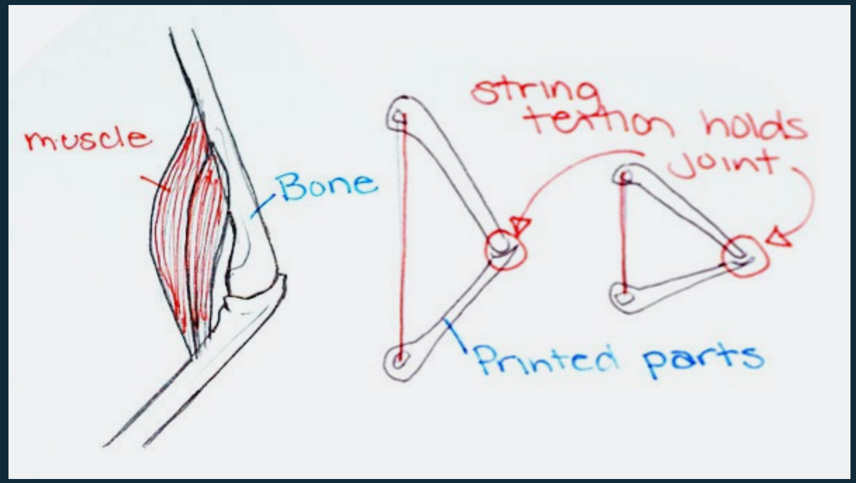
The joint system will be common among all pieces or a couple joints will be used to allow for greater variety. They should be easy and fluid for users to adjust.

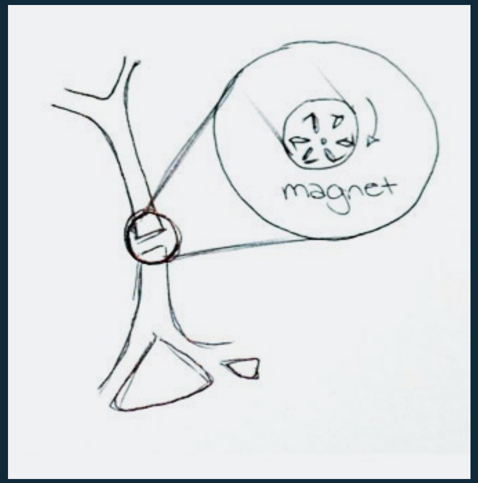


(Rutgers, n.d.)

Mechanisms

Based on the muscle and bone system tensegrity can be used between pieces, or magnets with steps can be used for a quick joint.



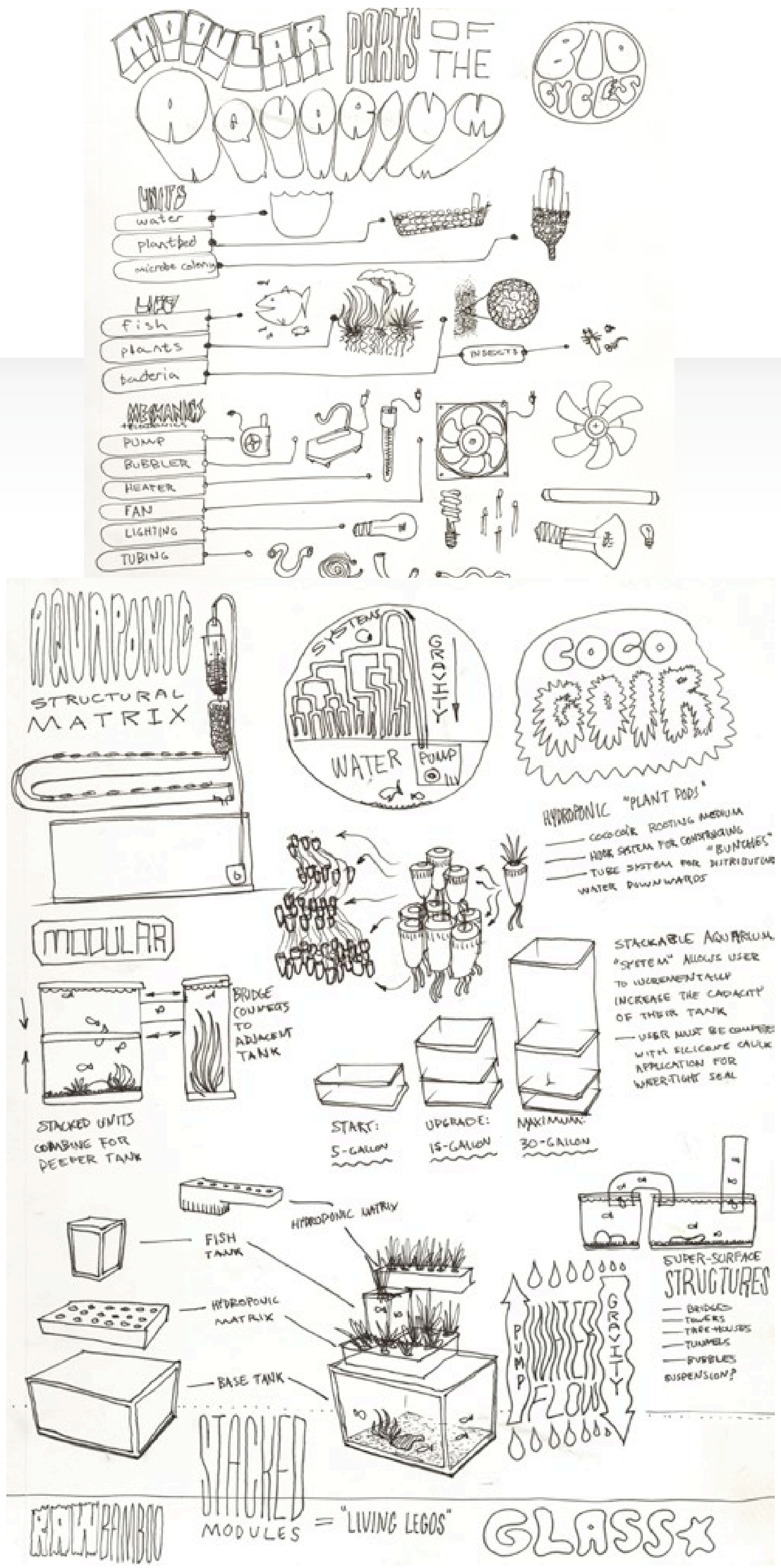


Outcomes: Concept
Nathaniel Williams

Constructing an aquaponic ecosystem is a unique opportunity to redefine the human relationship with nature and engage the senses for a more dynamic, rewarding experience . Rather than isolated organisms like fish in a tank or plants in a pot, an ecosystem is an interactive collection of organisms.

This super-organism takes the form of an animated display of aquatic life and lush vegetation growing in an interior space. Users can fine-tune both the size of their system from 5-50 gallons and select from all types of species to inhabit it. Animal options range from freshwater fish to crustaceans to turtles while the plant beds can grow flowers, herbs, and vegetables.

To provide a new digital perspective on animals via computers or smartphones, small digital cameras are embedded in the structure for a fish-eye view, and a basic digital microscope provides 250x magnification to zoom in on the life teeming out of sight. The tangible feedback in smelling a rose or biting into a tomato is visceral, a possibly intoxicating when the experience grows over months and months to a rewarding climax.

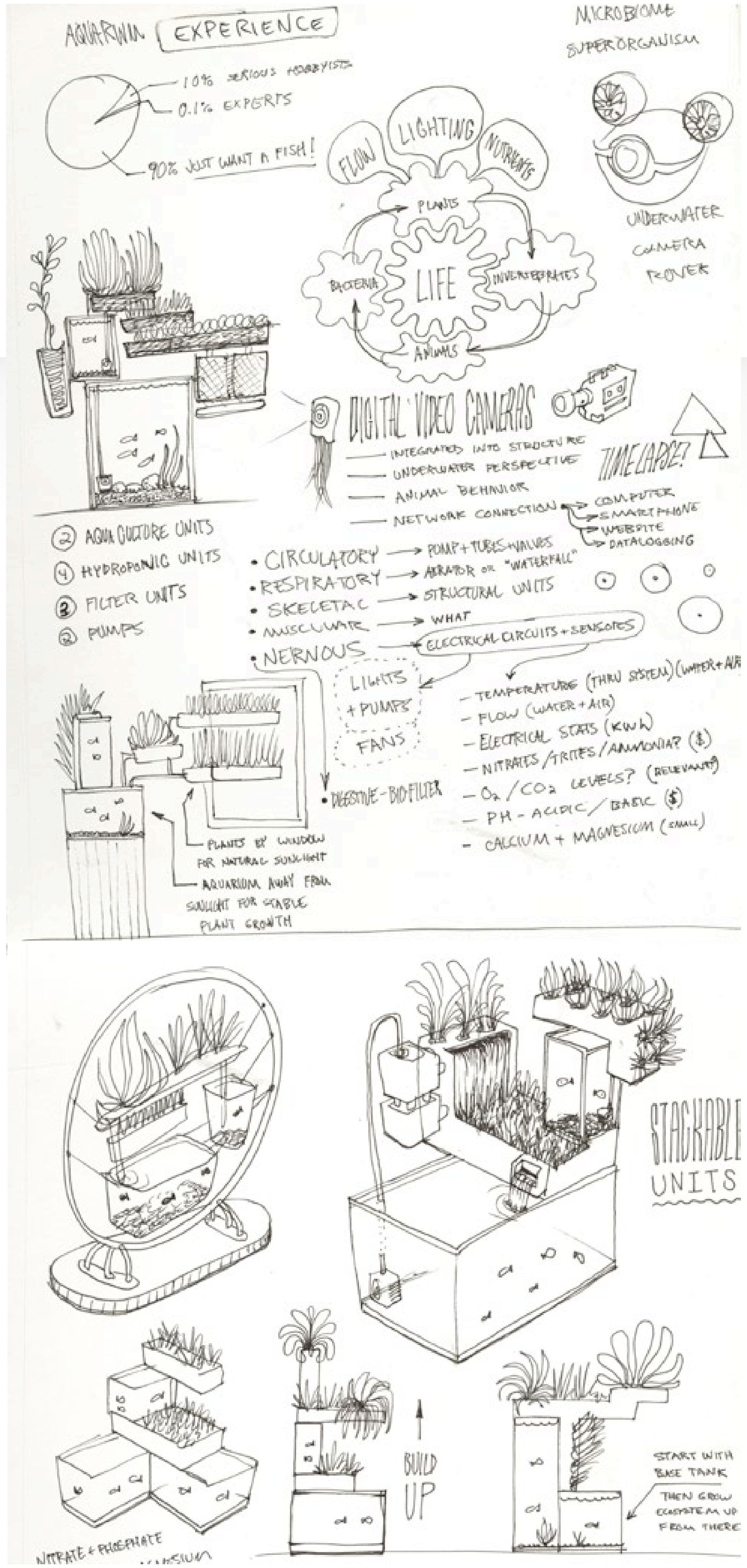


Interaction - The electronic 'nervous system' of the structure includes an array of sensors that provide digital feedback to enhance user connection.

- -Diagnostic sensors- temperatures, pH, flow, light exposure
- -Optical Sensors - underwater camera, microscope

Shape - The divisions created by cellular construction separates the trophic levels. This allows a wide variety of organisms to coexist that would otherwise damage each other. Because each unit plays a part in the total cycling of the ecosystem, the shape visually displays the overall flow of water and nutrients.

Assembly - Modular construction allows the user to build an assembly that fits their space, budget, and interests. The system can grow and shrink in a fluid manner should the user want to expand, contract, or reconfigure the system.



APPENDIX A: INDIVIDUAL BRIEFS AND SCENARIOS

An interactive mechanical sculpture
(Maker Faire Dublin, 2012)

Design Briefs:
Remy Godzisz

Above: School computer lab. (Teleread, 2013)

Background

I am developing under the category of education. More specifically I am looking at developing an educational prototyping tool for computer programming, helping overcome knowledge barriers. This in turn promotes children to be physically engaged in computer programming, learning through doing.

As technology continues to grow, skills such as programming are becoming increasingly sought after in the workforce, but school systems are still catching up to provide them.

Opportunity

There is a big opportunity in the field of prototyping and education. Hands on collaboration between children and instructors keeps children engaged while learning new skills, having fun doing so. Opportunity lies in developing new prototyping tools that nurture self-directed learning while lowering complex knowledge barriers for students. Programming is a category where there is a lot of opportunity to further develop in innovative ways. Currently programming is stuck onscreen and does not stray from the digital medium of a computer. It is also very complex learning how computers work and then on top of that learning the programming language. I look forward to capitalize on the opportunity here and develop new educational tools.

The End User

Children and students will be my focus as the end user. Though children are the end user, the school institution or adult will most likely be the one to purchase the item and therefore have to be taken into consideration. Hobbyists that are looking for an entry into programming may also be included.

Left:
Weselly, Remy and Mohammed

The User Requirements

An important user requirement is the ease of use. A tool is an extension of your hands used to build and should not feel foreign. It should quicken the development not hinder it. Factors that fall under ease of use are portability, simplicity and ergonomics and will be addressed.

Secondly the user requires a cost efficient solution. As one of the main targets is schools, relatively low cost tools are important to allow more realistic integration into various institutions without price being too much of a concern. Engagement and interaction is an important requirement for the product. With hands on approach it is important for the user to be able to jump into the experience and have a sense of control.

Outcomes / Possible Solutions to Achieve Outcomes

The key outcome that I would like to achieve is developing a project that results in the user learning while engaging. More specifically I will look at the subject of computer programming, something that is generally done on a computer and little physical engagement.

To achieve this outcome I am looking to develop a tool that creates a physical interactive experience in learning computer programming. As programming is a digital language, I do want to incorporate digital aspects with physical components to complement each other and create an overall more unique and educational experience. This system will address some of the general hardships of programming, such as complexity and debugging, letting the user prototype without being hindered too much.

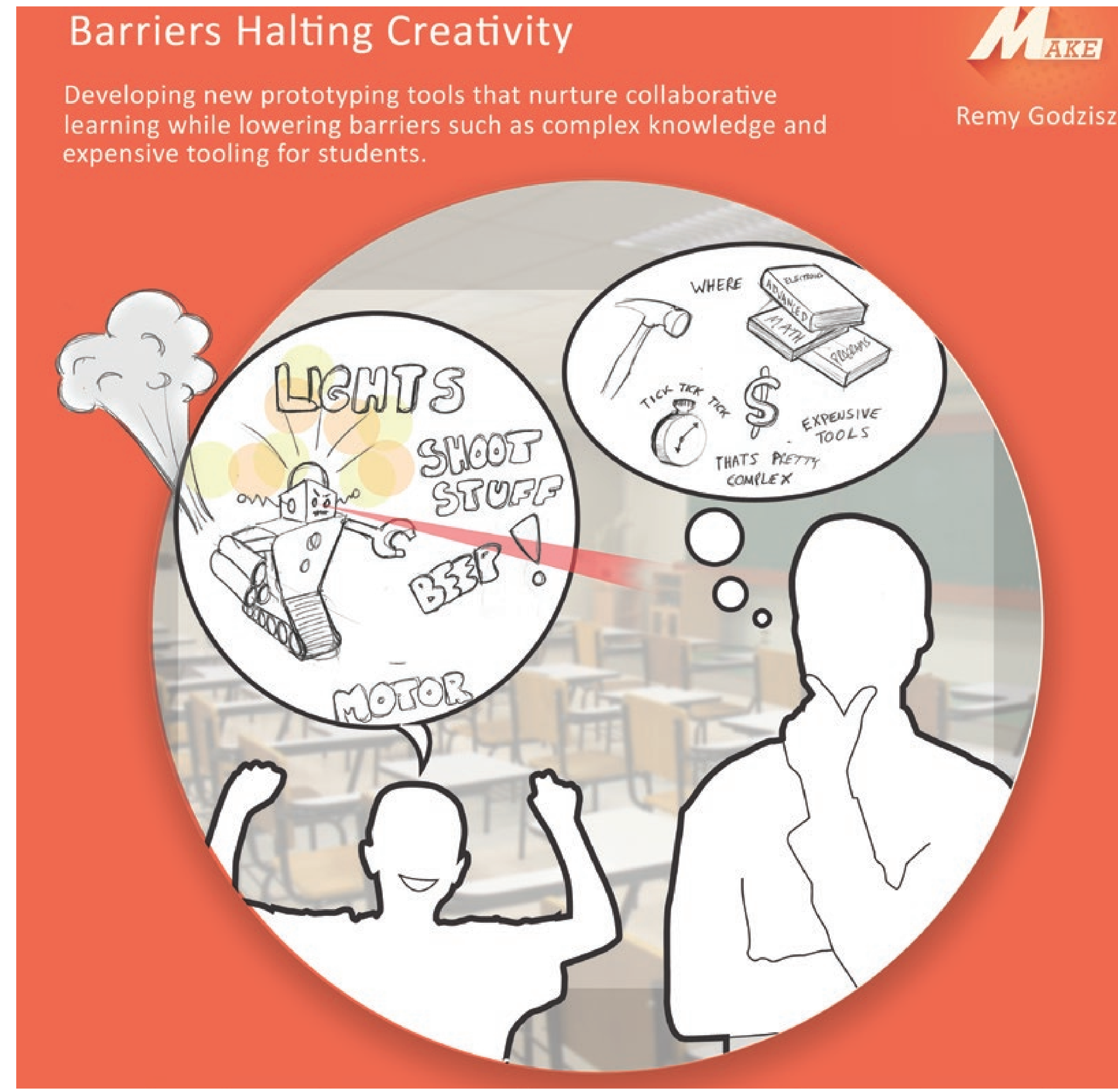
I will continue to stay in touch and work with contacts I have made to help achieve the desired outcomes.

Remy Godzisz
Next Steps:

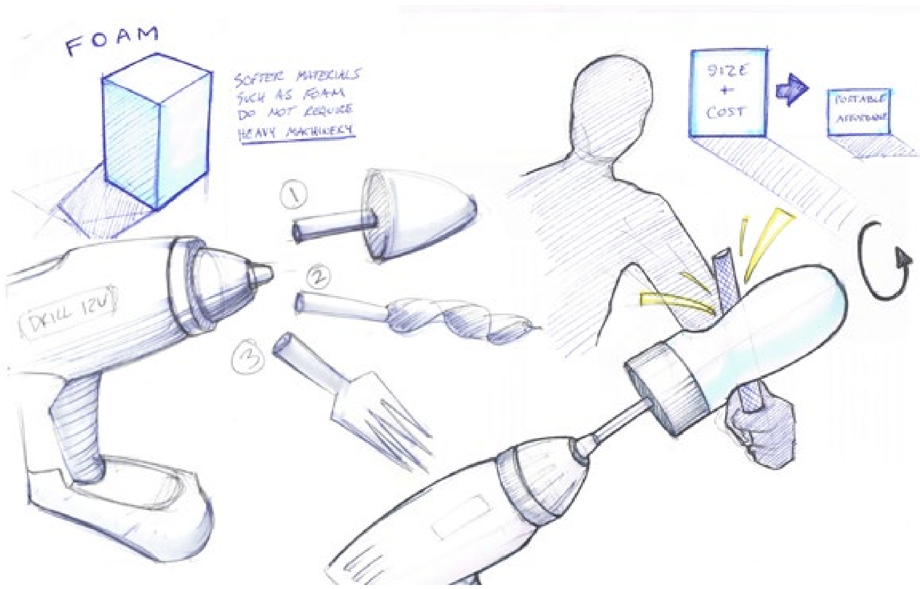
To further my concept to the next phase, I have laid out three steps to follow:

1. I will continue to work with members of the programming community as well as educators to refine and validate my concept.
2. Develop many prototypes (mockups and functional) to test design aspects and their integration with each other.
3. Determine technologies I plan to use for the project and how they will integrate to create a complete system.

Remy Godzisz
Scenario Board:



Remy Godzisz
Initial Concepts



Portable Power Tool Attachments

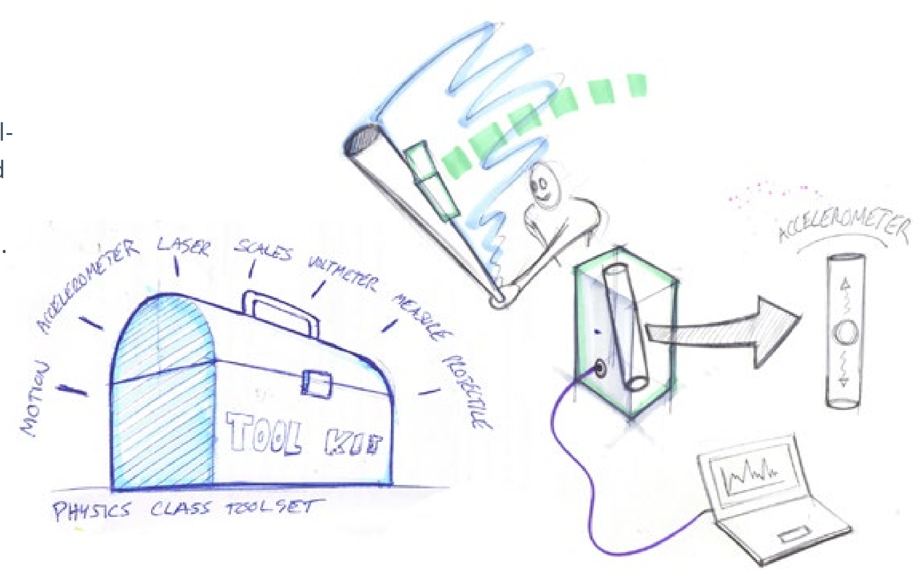
One of the first concepts I came up with for developing prototyping tools was to look at attachments to common power tools. This would relieve large tooling costs and size of machinery, making the tools available to a wider audience and increasing the portability. Materials such as foam do not require the power of heavy machinery such as a wood lathe, but these light materials are used quite often for developing prototypes. In the shops here at Carleton, it is common to see foam being used with the metal lathe. This seems a little overkill and a big task to go through. Smaller scale alternatives utilizing common tools in the household would provide quicker ways to create prototypes.

Physics Tool Kit

An idea that came to mind was to simplify electronic measuring devices such as accelerometers and scales. These devices could be easily paired with a computer and accompanying software to visualize the data.

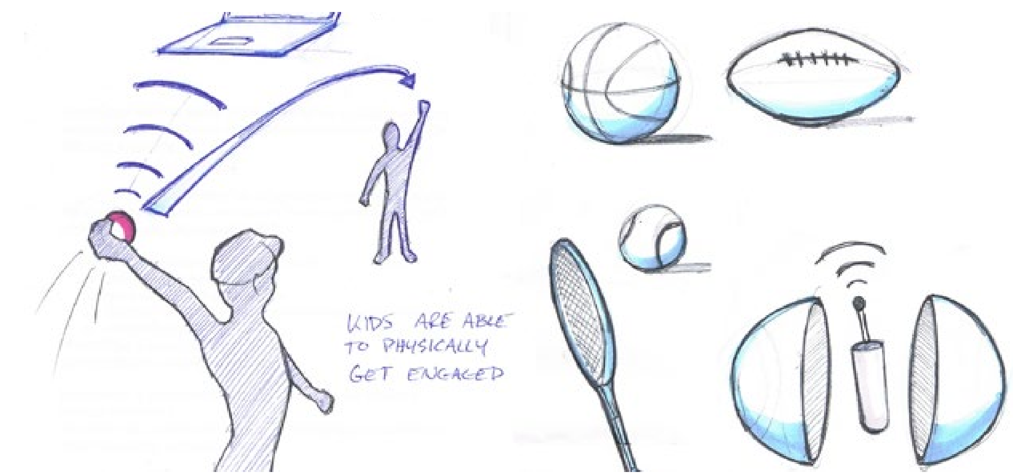
This tool set could be very helpful in the physics classroom where experiments are a big part of the curriculum. Looking back at physics class, the experiments where you got to get up and physically engage were always the most enjoyable.

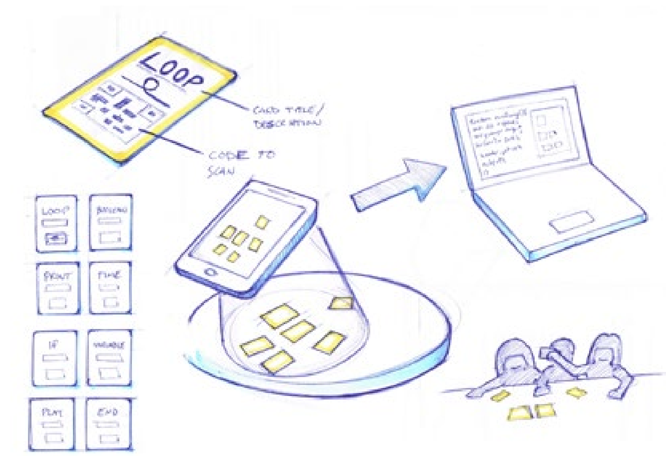
These tools could easily attach to prototypes for testing.

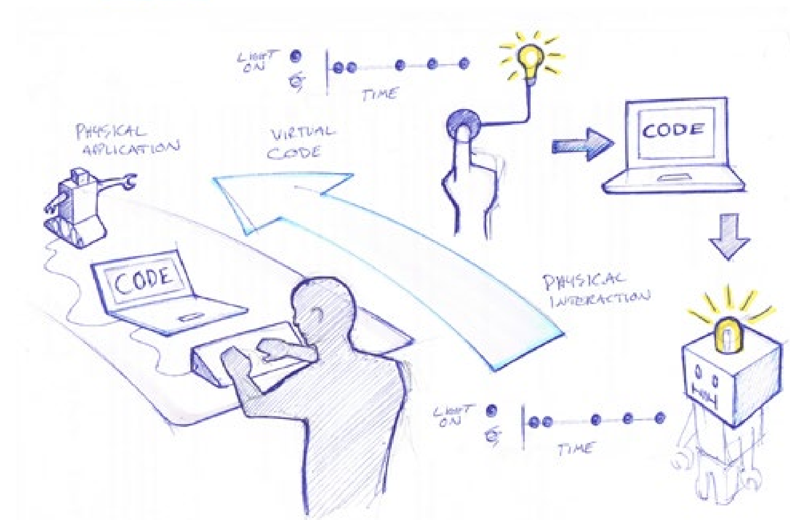


Physics Measuring Tools in Sports Equipment

Taking the last concept further, this looks to take measuring devices and directly fuse them into sports equipment. In the setting of a physics class it allows students to get out of their chairs and dive into the action. The measuring devices such as accelerometers transfer data based on the motion and force of the ball to a computer to be analyzed.







Computer Programming Deck of Cards

I started thinking about computer programming as a path to go down, looking into how new ways to teach it. One idea that I came to was creating a deck of cards with programming structures and systems on them. The users could group cards together using programming methodology to gain understanding of the control of information and how the pieces fit together. This could alleviate the need to worry about tedious aspects such as syntax errors. The cards would then transfer to computer where code is generated from physical arrangements of the cards.

Physical Console for Programming

Continuing to look at programming, I was looking at different ways to add the physical interaction aspect. Similar to a DJ's turntable, this console would allow the user to complete programming tasks through engaging the console. For example the user could press a button multiple times in a pattern to turn on an LED. This timed pattern of turning on the light could then be translated into computer code turning on an LED in that same pattern.

Design Briefs: Nathaniel Hudson

> Doing is what matters. Makers learn to make stuff by making stuff. Schools often forget this as they endlessly prepare students for something that is going to happen to them next week, next year or in some future career. Students can and should be scientists, artists, engineers and writers today.
> -Sylvia Libow & Gary Stager (2013)

Left:
A child and his father examine a trebuchet at 2012 Portland Maker Faire (OMSI, 2012)

Context & Introduction

40,000 students in Canada drop out of high school every year (Rogers Communications, n.d.). Furthermore, Canada faces widespread skill mismatches, with many unemployed workers unable to fill open skilled jobs (Flavelle, 2013). In addition to this, job training is rapidly becoming a thing of the past, requiring independent and collaborative learning skills to fill the gap, skills which new graduates often lack (Flavelle, 2013). Our schools are failing to engage students and to impart the learning and entrepreneurial skills necessary for today's world (Robinson, 2013). To combat this, many educators and institutions are turning to the maker approach to learning, an approach that values building and iterating, as well as leaning through experimentation (Libow & Stager, 2013).

> Educators, especially in the primary space, are finding their efforts stymied by a lack of appropriate facilities.

Opportunity & Challenge

Unfortunately, educators, especially in the primary space, are finding their efforts stymied by a lack of facilities appropriate for this new approach to learning. With space in schools becoming scarcer every day, not all schools have shop facilities available. Even among those that do, the facilities may be overbooked, excessive for the needs of students, or simply inconvenient. Additionally, time is extremely limited, and moving the entire class to the workshop can make working there impractical.

I believe that rather than bringing the class to the workshop, the workshop should be brought into the classroom. This can be accomplished through a system of tool carts which will allow the tools to be brought into classrooms.

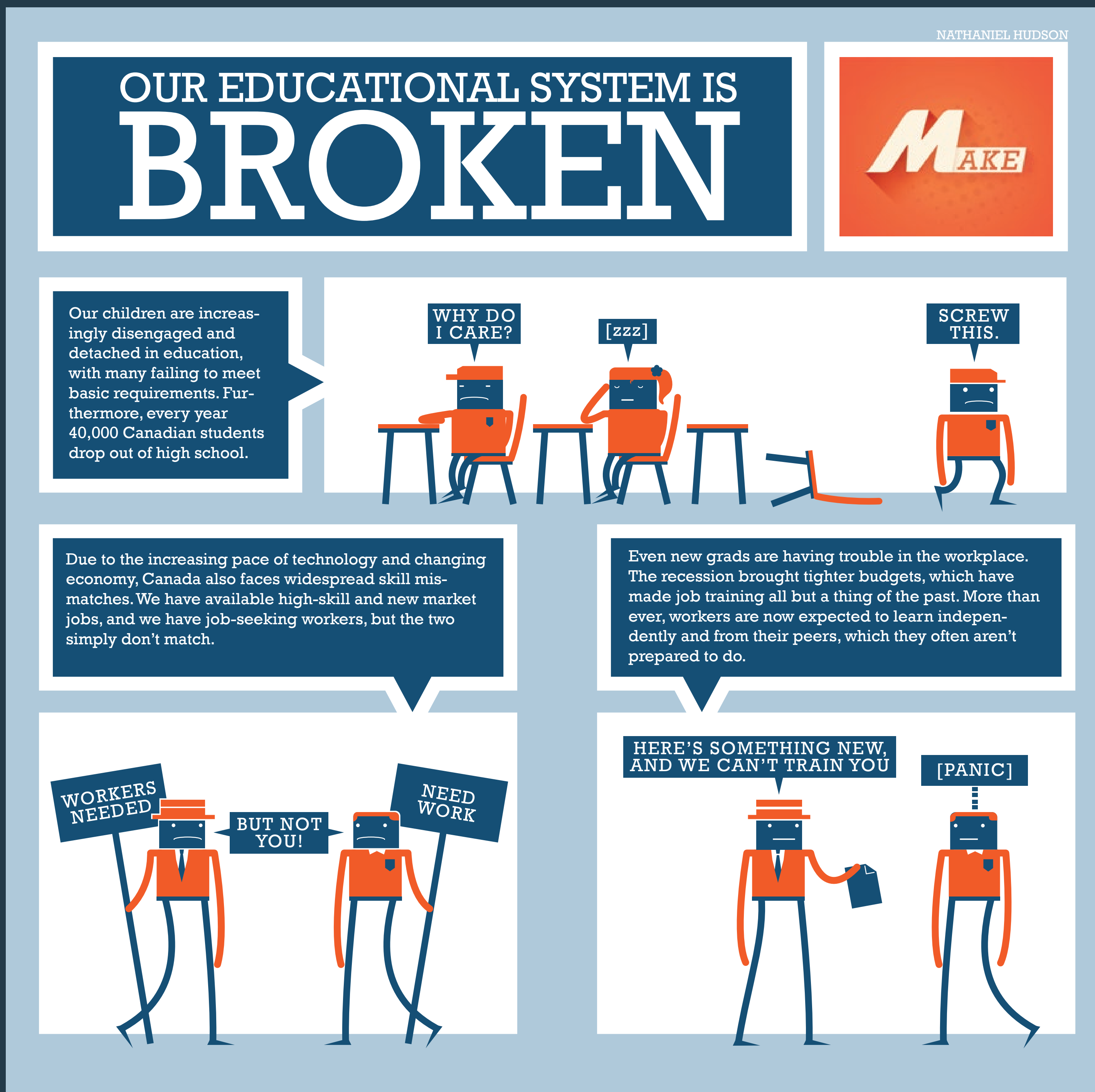
User Requirements

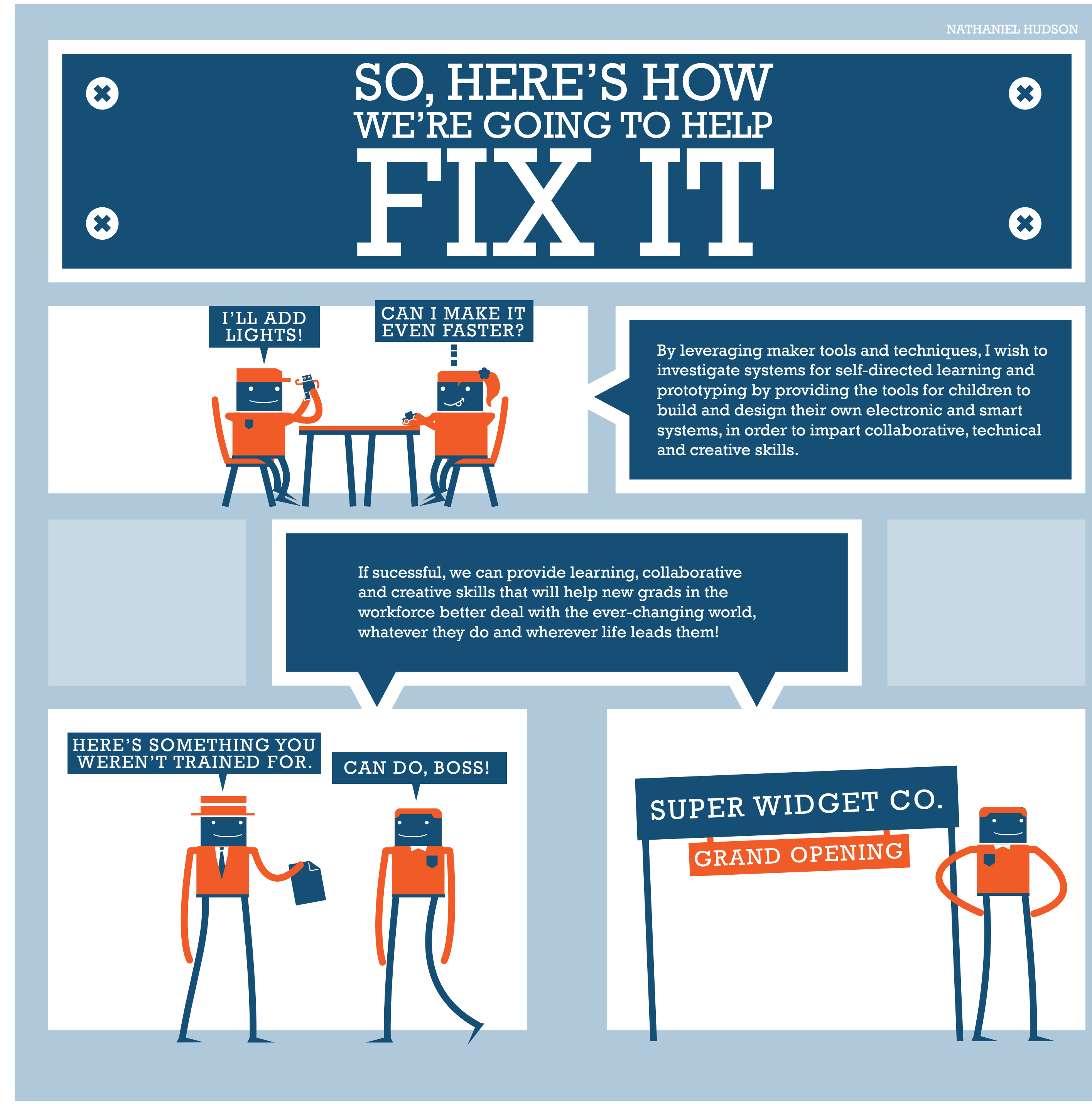
The natures of the maker movement and the educational world both pose unique challenges. Unlike most other products, successful "maker" products are aimed not at solving all a user's problems, but rather they provide resources that can be combined in ways unforeseen to the designer. Education requires attention to the unique nature of students, such as their schedule, diverse (and often eccentric) interests, different levels of ability and disorganized (and occasionally destructive) nature, as well as the needs of both educators and educational institutions, including safety, ease and comfort of teaching.

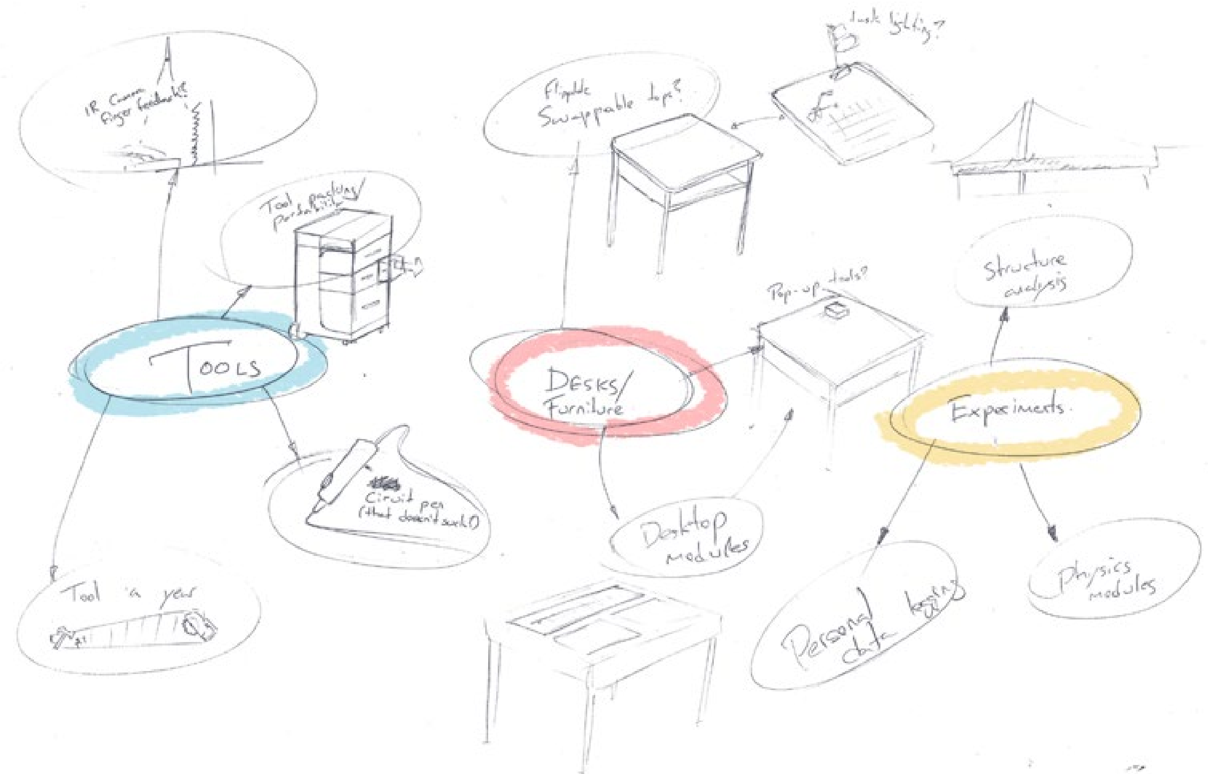
Measures of Success & Learning Outcomes

I would define success to be the ability of the product to assist teachers in bringing making and student-led experimentation into the classroom. I'm interested in learning goals such as teaching the value of mistakes, the value of iteration, and the ability to produce physical objects. Above all, I want my product to help inspire and excite a new generation of learners!

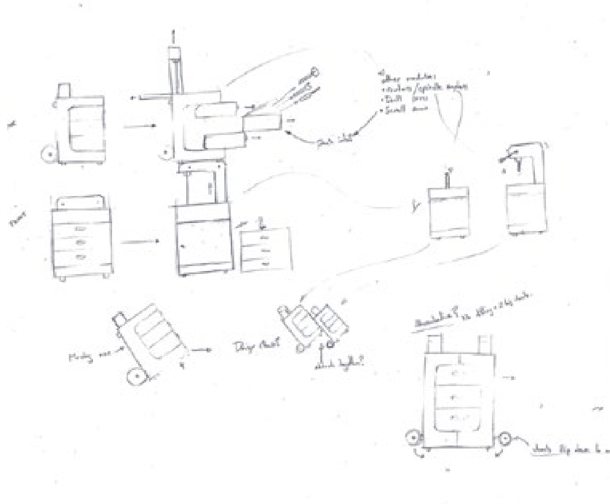
Scenario Boards: Nathaniel Hudson

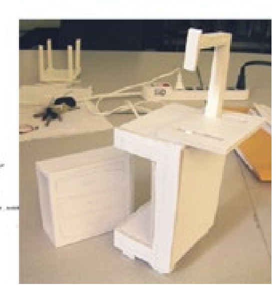






Nathaniel Hudson
Early Concepts



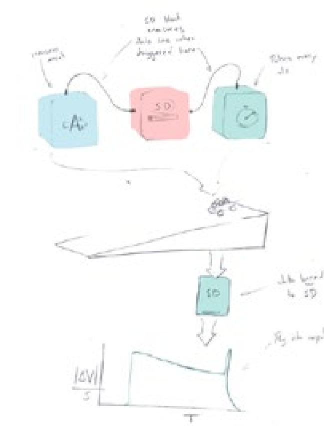


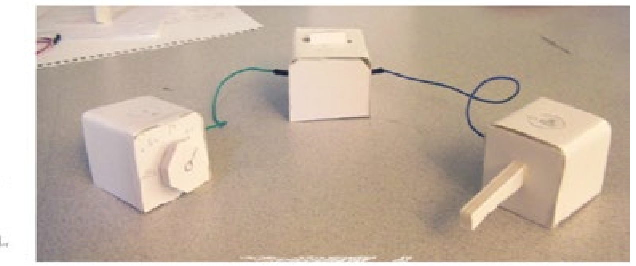
Above: Based on the research concept development centered around three key areas: Tools for education, Furnishings enabling making in education, and devices for Experimentation.

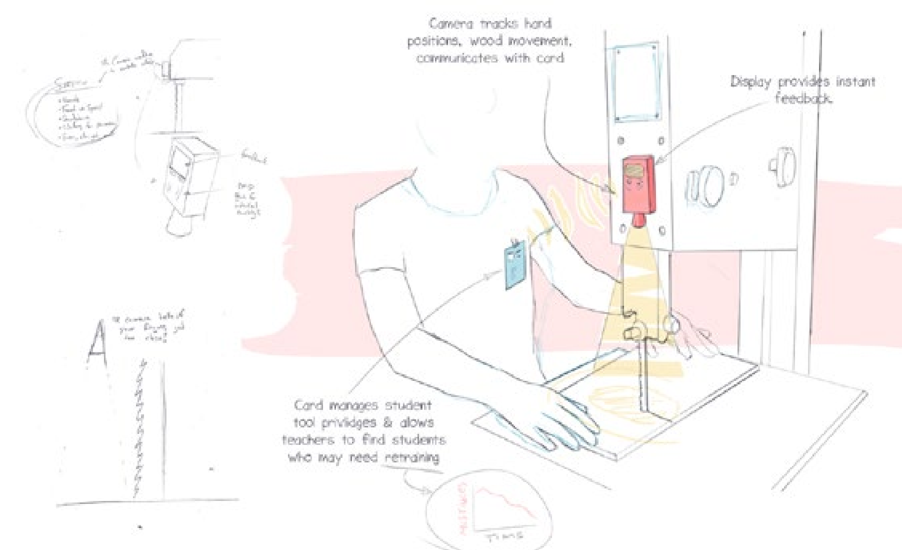
Left: The conversation with Dr. Purchase revealed a desire to be able to not tie the workshop to a specific location, rather to have the workshop move to wherever the students are. This would carry benefits both in terms of space booking and timing, as teachers could allow for workshop time without ever leaving the class. Dr. Purchase also suggested that this could be used as an opportunity to enhance the design in order to make the tools as non-intimidating as possible for both students and instructors.

One final topic discussed with Dr. Purchase was the ability of students to design their own experiments in physics and geometry.

This could take the form of a modular system that would allow students to quickly take measurements of things like acceleration, rotation, torque, distance and time, such that they could design their own experiments to measure things like the force of gravity or the co-efficient of friction on a given surface.



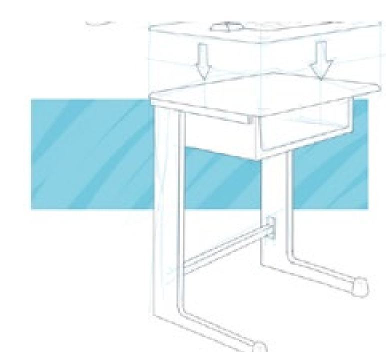


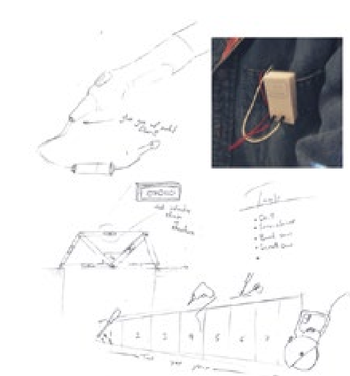


Left: Safety is the number one priority in any school workshop setting, which presents a real challenge to teachers su-pervising a classroom of inexperienced students in the workshop. By building a smart system that can monitor basic safety factors when using shop tools, we can provide both real-time feedback to students as well as metrics for teachers to identify students who may need further training. While no system can ever make a workshop completely safe, by addressing basic errors early on we can prevent serious accidents in the long term.

Left: During the interview with Mr. Smith, we discussed multi-use furnishings that could very quickly shift from a tradition-al classroom to a space more suitable for con-struction, experimentation and making.

Far Left: Additional concepts such as personal data logging, solvent-free circuit pens, tool cur-riculums and structure analysis tools were examined, but ultimately not pursued.





Nathaniel Hudson
Project Focus

Essential

Safety Features
Curriculum Relevance
Speed of Setup
Durability

Benefitial

Organization
Teach “Real-World” Skills
Simplify Administration

Exploratory

Manage Power and Noise Concerns
Reduce “Tool Intimidation”
Hackability / Open-Source Aspects

NEXT STEPS

Short Term

- Start making simple functional prototypes
- Determine specific tool combinations for carts

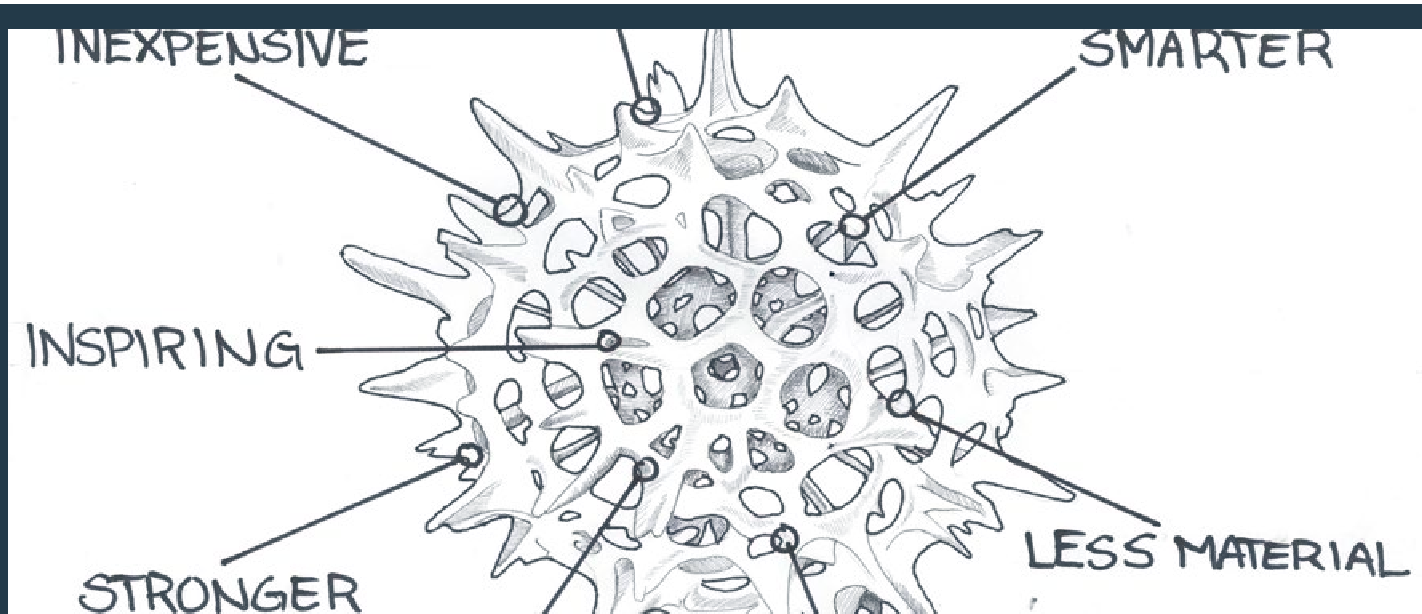
Medium Term

- Build semi-functional models for testing
- Refine and focus feature list

Ongoing

- Continue validating concepts with the maker and educational community

Design Briefs: Kristine Vodon



> We are on the brink of a materials revolution that will be on a par with the Iron Age and the Industrial Revolution. We are leaping forward into a new ear of materials. Within the next century, I think biomimetics will significantly alter the way in which we live.
>
> - Mehmet Sarikaya, materials science and engineering professor

Context & Introduction

Rapid prototyping is becoming widely accepted and slowly more affordable. It is being used increasingly by the maker movement as it eliminates a lot of the challenges and limitations of traditional manufacturing techniques. This is a huge community, and unfortunately not everyone is able to take advantage of 3D printing because of the need for complex software and a lack of awareness to many people. Currently, the 3D printing model is often perceived as a linear model that produces small plastic parts that simply end up in land fill because of the materials we currently use. The objects that are printed are mostly static objects where all the design is in the CAD work.

> "Following nature's design mastery we can achieve greater wealth and economic sustainability. We can do this without sacrifice, while protecting our planet." - Jay Harman

Opportunity & Challenge

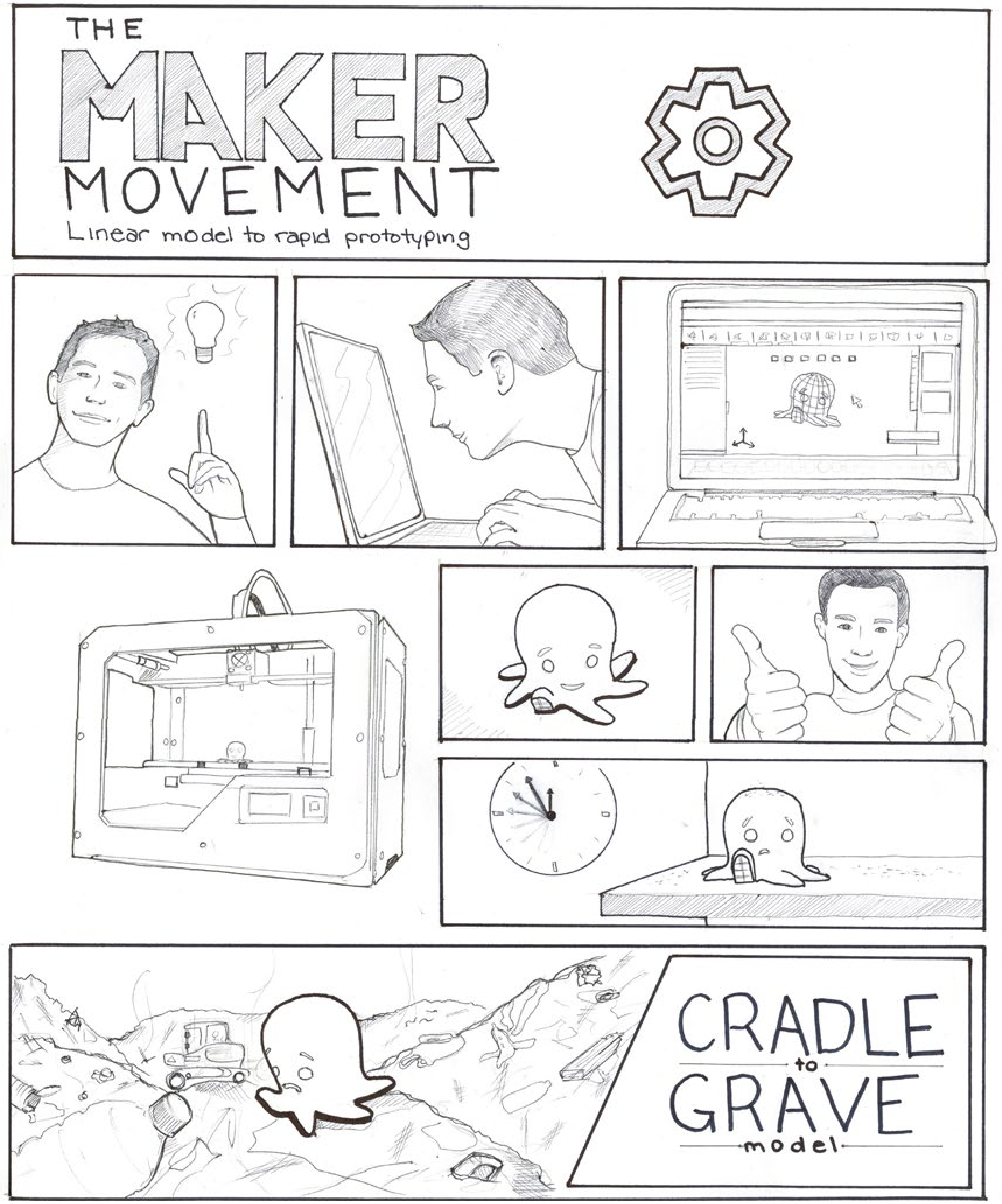
Breaking through the barriers to 3D printing with a biologically inspired product can have a dual effect on its users. It can bring both creative, biological inspiration, and it can allow the benefits of 3D printing to reach a wider audience who are unable to grasp the CAD aspect of the process. Janine Benyus (author of 'Biomimicry: Innovation Inspired by Nature) believes 3D printing is the key to a new revolution in manufacturing that will be available right in the home. "we stand at the cusp of a new paradigm in manufacturing, and the decisions that designers make now regarding the materials they use will have lasting effects. As 3D printing technology continues to develop, it has the potential to blossom into a full-fledged sustainable manufacturing revolution. Be that isn't the course we're currently following."

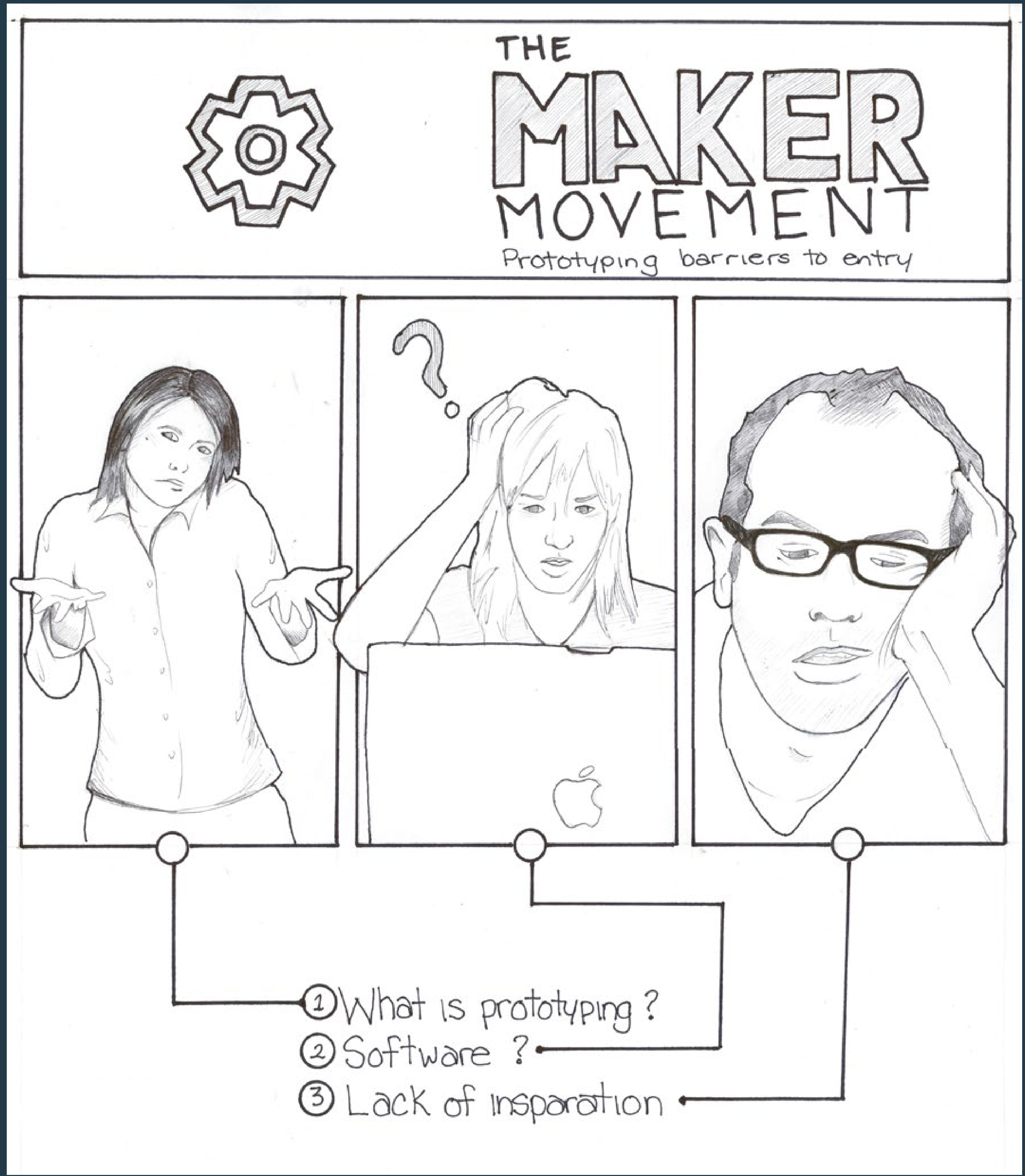
User Requirements

The maker community has no age limitations or discrimination of any type. It is made up of people who have a personal drive for the satisfaction of making something uniquely their own. For this reason, it is very art to predict the background a user may have. To increase engagement in the maker community any product should be easy and intuitive to learn while still allowing for freedom and creativity.

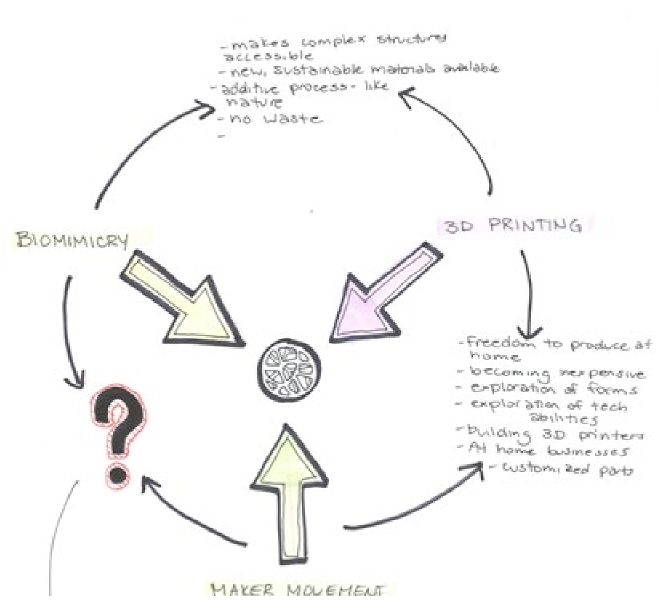
Measures of Success & Learning Outcomes

A product that will communicate biological inspiration through structures and materials and break the barriers to the prototyping process of 3D printing. A project that is both functional and inspiring, that uses resources efficiently and serves as a small step on the path to sustainable design. If I can design something that can be modular like lego, yet fluid like sculpting, with aesthetics that allow users to create a final product they can use and enjoy in their everyday life, that would be the ultimate measure of success.


THE
MAKER
MOVEMENT
Linear model to rapid prototyping
CRADLE
to
GRAVE
model


THE
MAKER
MOVEMENT
Prototyping barriers to entry
① What is prototyping ?
② Software ?
③ Lack of insparation

Kristine Vodon
Early Concepts

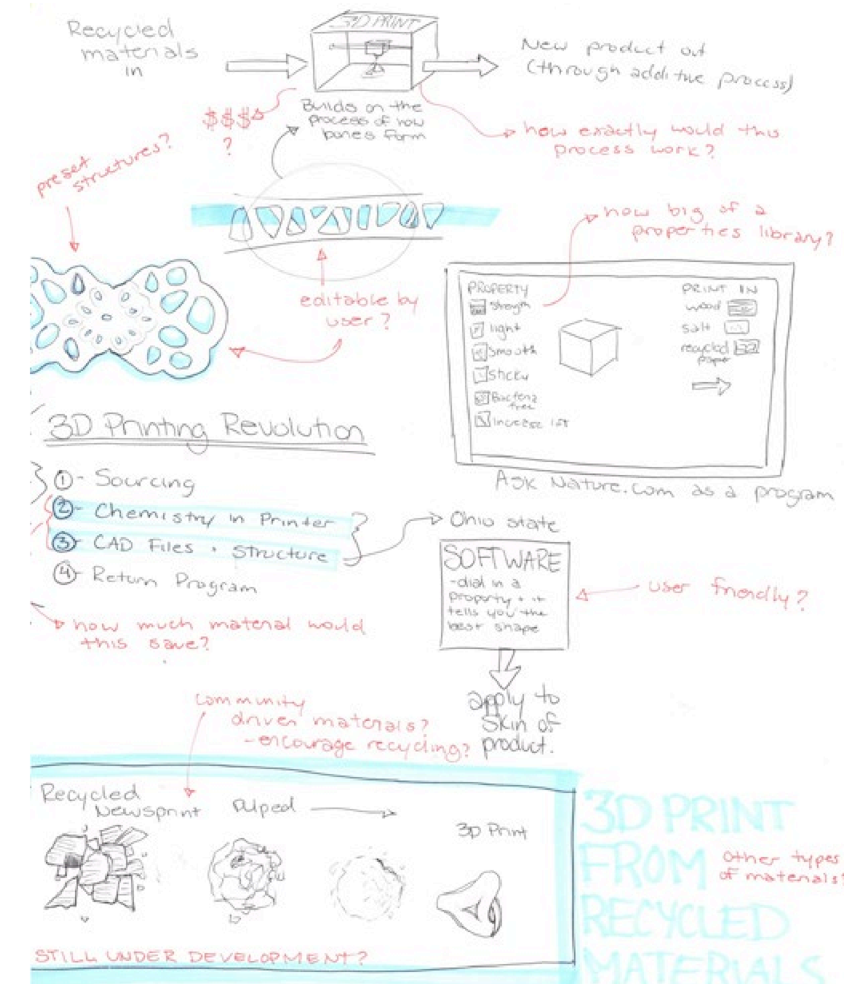


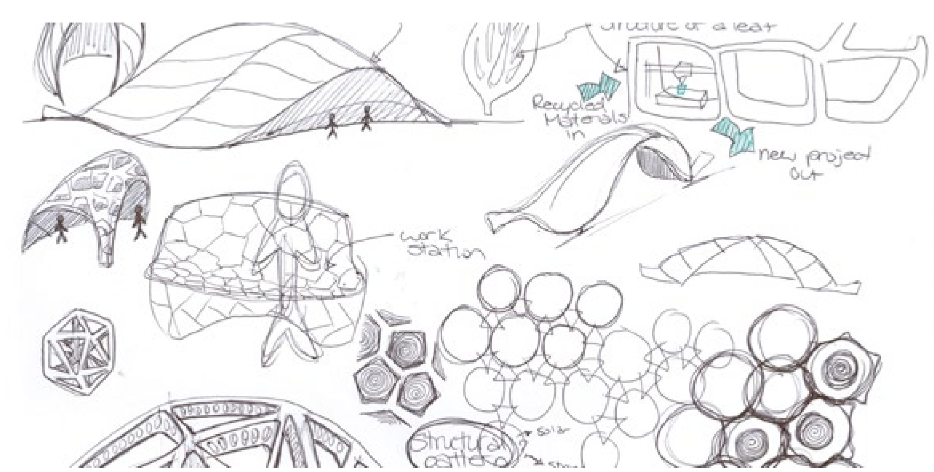
Above: Based on the research my initial idea was to create a structure that bridges the gab between biomimicry and the maker movement. This would be an inspirational maker space that would act as a biomimicry toolkit and collaboration hub.

Left: The driving theory behind each concept was the realization that biomimicry is not accessible to the maker movement. At the intersection between biomimicry, the maker movement, and 3D printing I can see amazing things happening towards a more sustainable future where a lot of manufacturing can be done in the 'makers' homes - as it has already begun to. Filling this gap would be a step towards making people who are building their own products more aware of their environmental impact.

Right: One of the areas that my early research led to was the concept of making more sustainable materials more accessible to the maker movement. Materials play a huge role in the design of any product as it determines its life-span, life-cycle, and functions within its use. Reusing materials is something more processes should take into account, but many do not. 3D printing is one of those processes that generally ignore the use of sustainable materials but instead goes for the cheapest, readily available and easy to use materials. There are companies such as Emerging Objects that are developing new 3D printing techniques to print in new or recyled materials.

If there was a product, software or new 3D printer that allowed 3D printing to use recycled materials from around the house I think that would be an amazing feat, however; it is outside of the realm of this project and may not be feasible with the existing technology.





Left: More iterations on a collaborative space that could have been used as a biomimicry collaboration space for makers, biologist, children, families and the community. There were a lot of implementation issues such as how the structure would work in winters, how large it would have to be, how it would generate power, how it would be funded, and how it would be managed.

Nathaniel Williams
Early Concepts

Context

On the material focus of the maker spectrum, toying with modular construction is a wildly effective way to engage people's minds with reality. Whether building with sticks and stones, wooden blocks, or chunks of plastic, the ability to arrange and quickly rearrange units lets people materialize ideas as quickly as their mind moves. The enormous success of construction systems such as Lego (profits of $7.5 billion in 2012) speaks to humans' fixation on creation.

The variety of modular construction systems available ranges from flexible plastic K'nex to rigid metal Meccano; various materials offering advantages and a unique assembly syntax. Mechanisms ranging from simple levers to complex electric motors engage makers with animated interaction. A static model of a boat can be beautiful; a remote-controlled boat offers an interactive experience. Making creations "come to life" adds another level to their value.

Opportunity

Bringing mechanical "life" to creations is a concept that may physically fly over one's head in the form of a DIY quadcopter, but mentally can be fully appreciated by almost anyone when handed the controller. Expanding such immersive experiences from purely technical interactions to include biological interactions presents an opportunity to exponentially increase people's connection to "making".

User Requirements

Growing and prototyping with vibrant ecosystems engages the maker with variety of interactions, presenting the challenge of maintaining harmony within a miniature biome through learning about earth's living cycles that sustain our existence. Makers need a structure they can reconfigure and modify to frame such biomes. This framework must afford a wide range of assembly possibilities and visually communicate the cycles that power life.

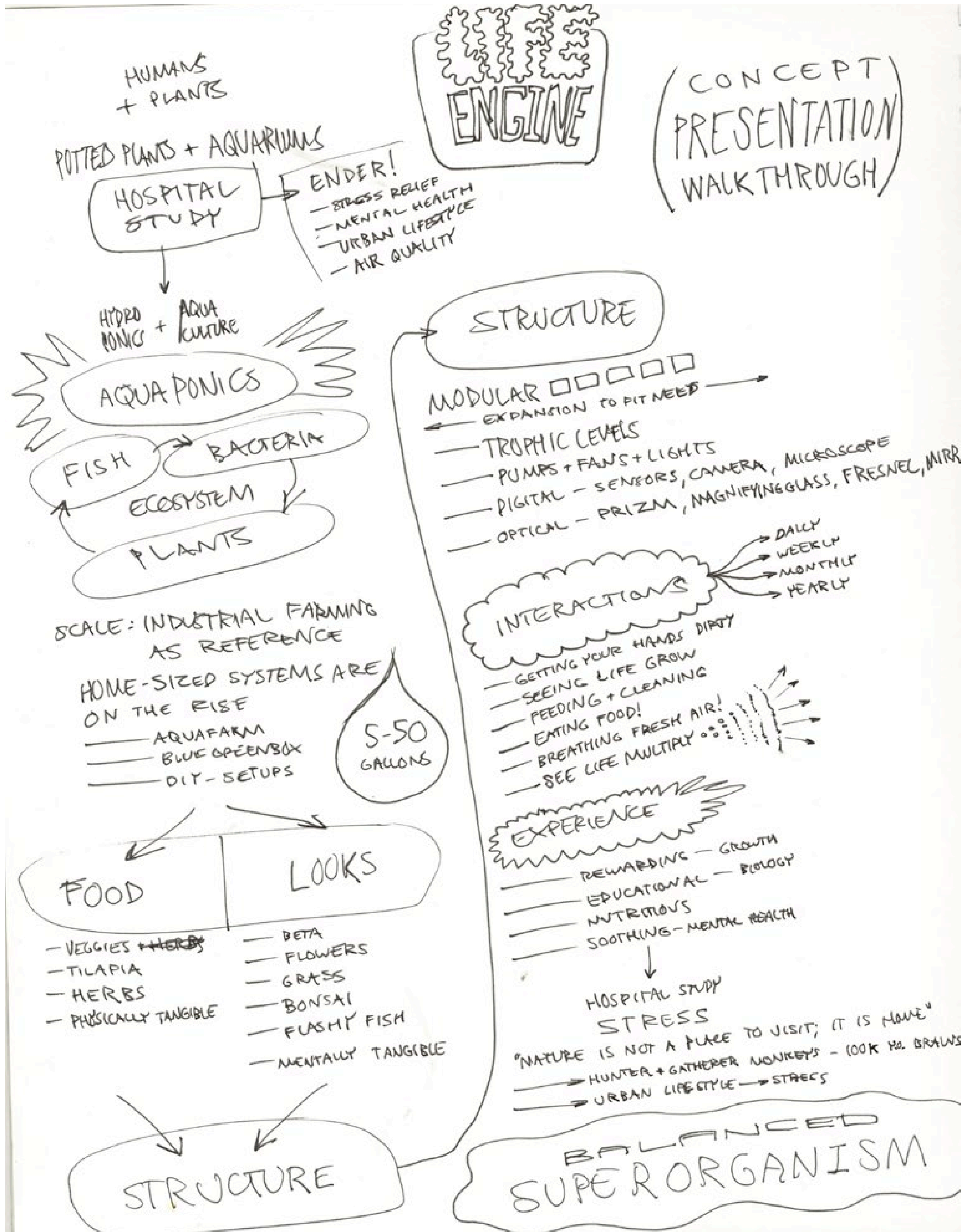
Measures of Success

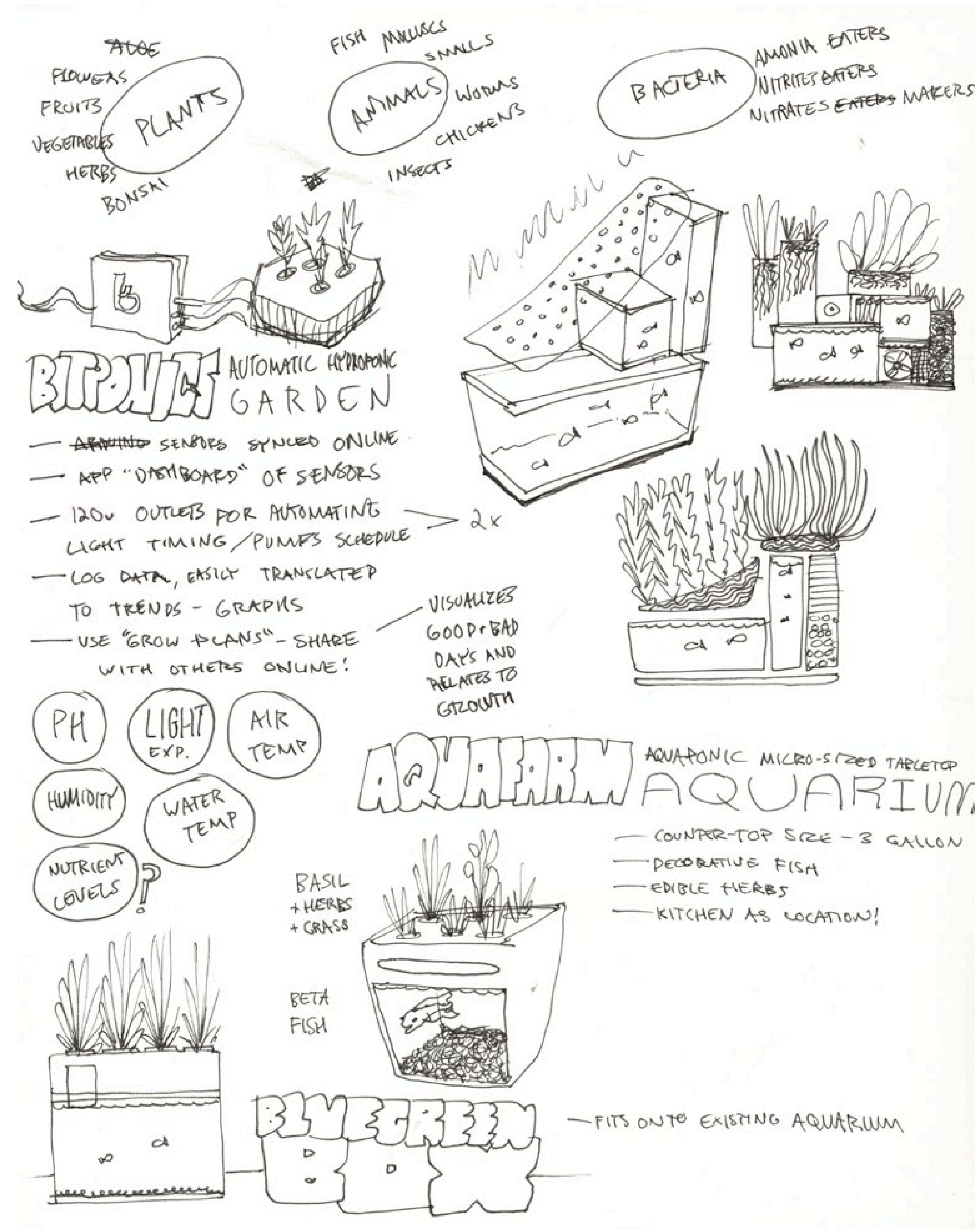
The success of creating modular ecosystems can be measured by the maker's level of engagement. Ideally, such an apparatus would facilitate hands-on learning, materialize as healthy community of organisms, and unconsciously inspire a deep appreciation of the gorgeous balance of cycles in our biosphere- Earth.

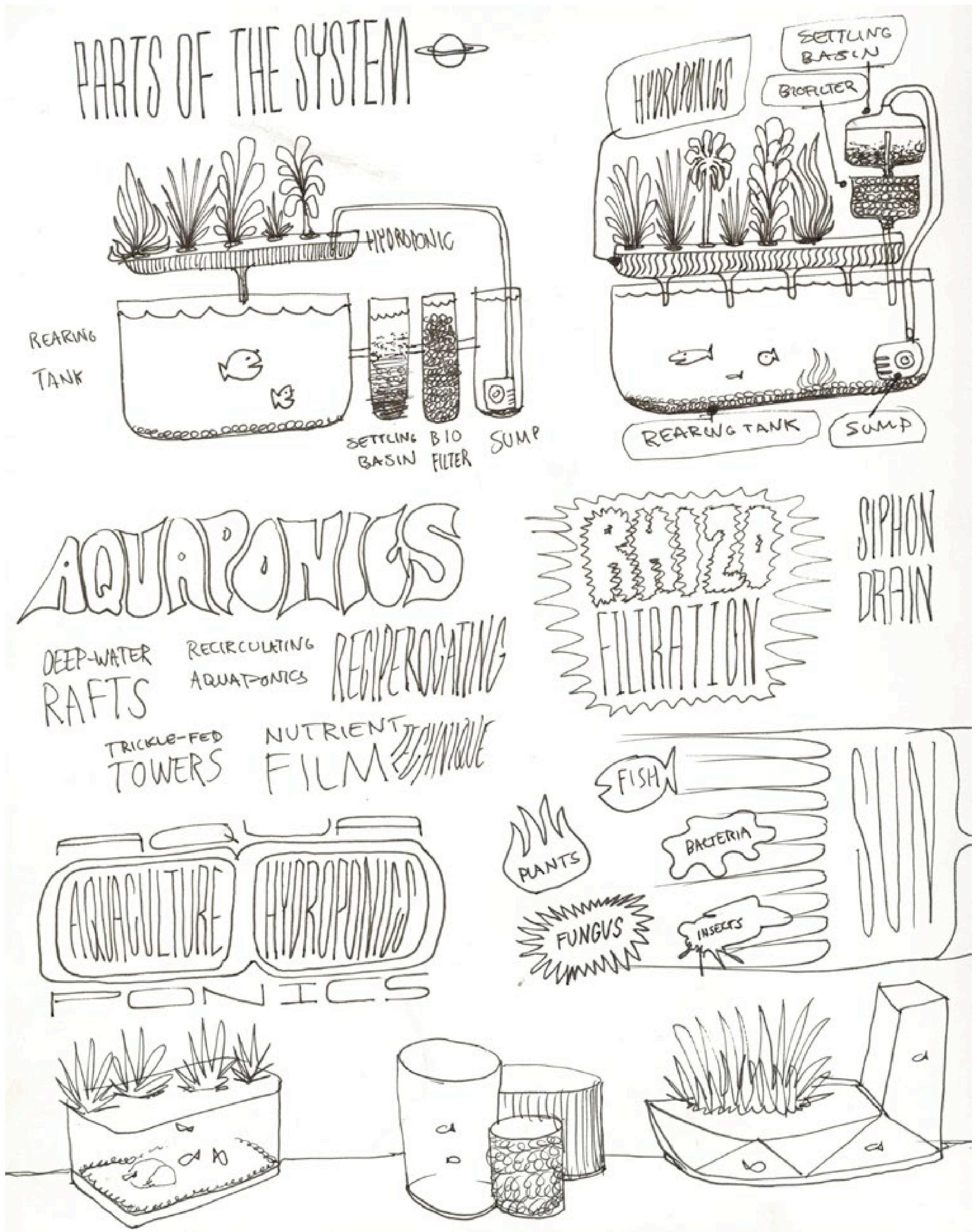
External Contacts

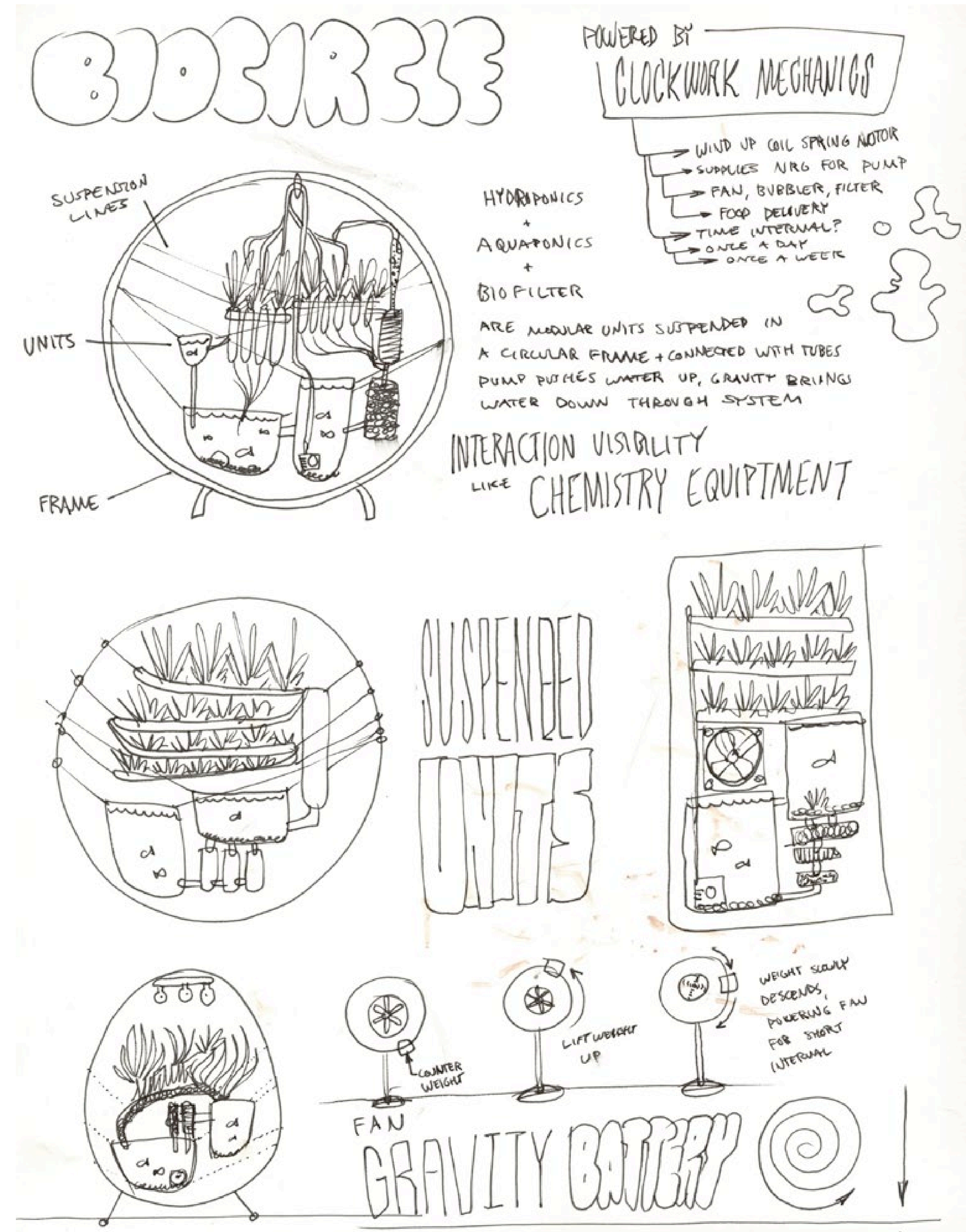
- Steve Lenox - Manages exhibition design at Lyons & Zaremba, a firm out of Boston specializing in nature displays such as aquariums.
- ArtEngine Ottawa – A group comprised of extremely knowledgeable "techie" makers with open minds and diverse skill sets.

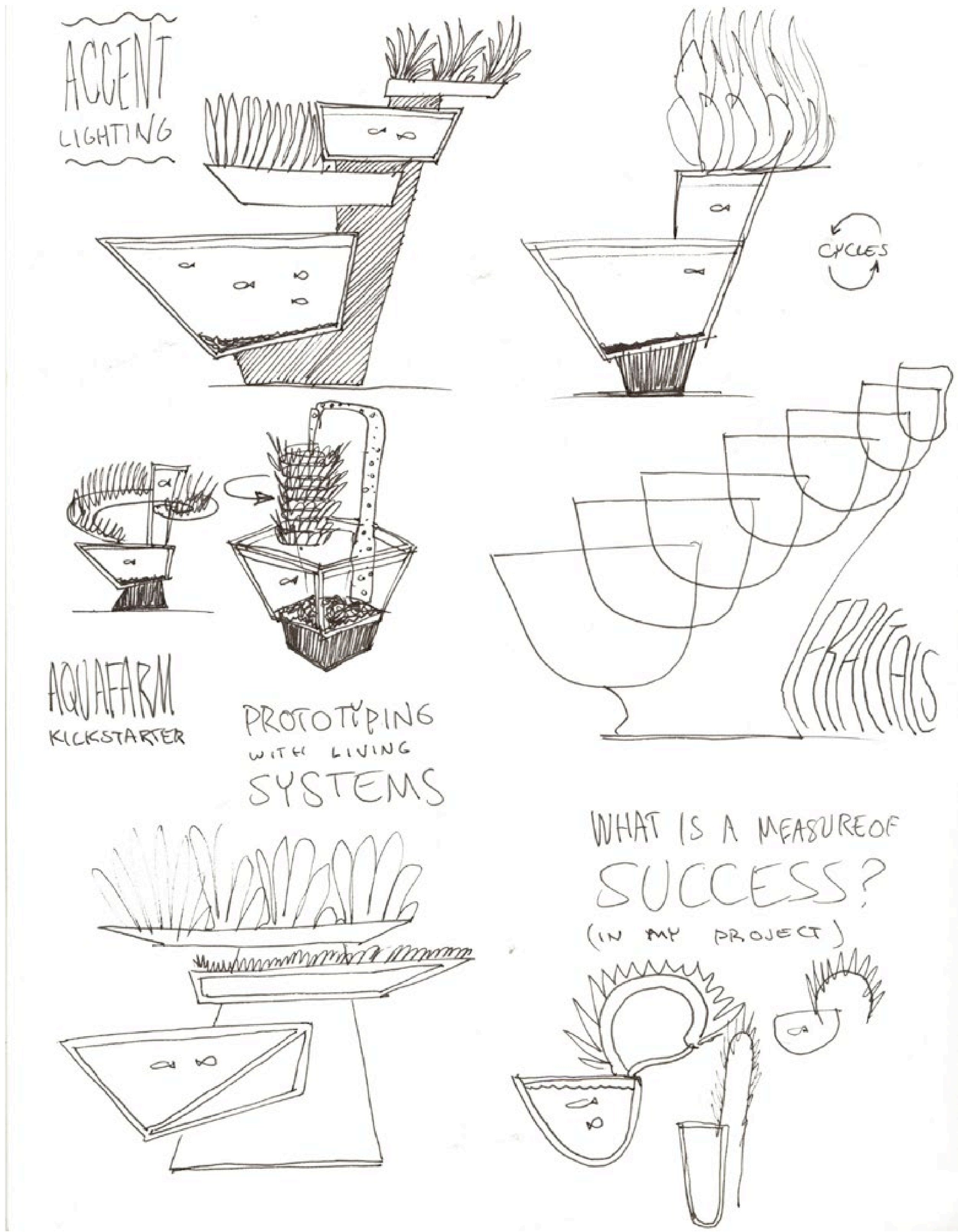
My personal aquariums are ongoing experiments, and the chief inspiration for this project. I regularly modify the structure, create my own filter mechanisms, and have recently added the glass 'treehouse' on the right that allows fish to swim above the waterline. The turtle sometimes swims up as well, though much more cautiously than the fish.

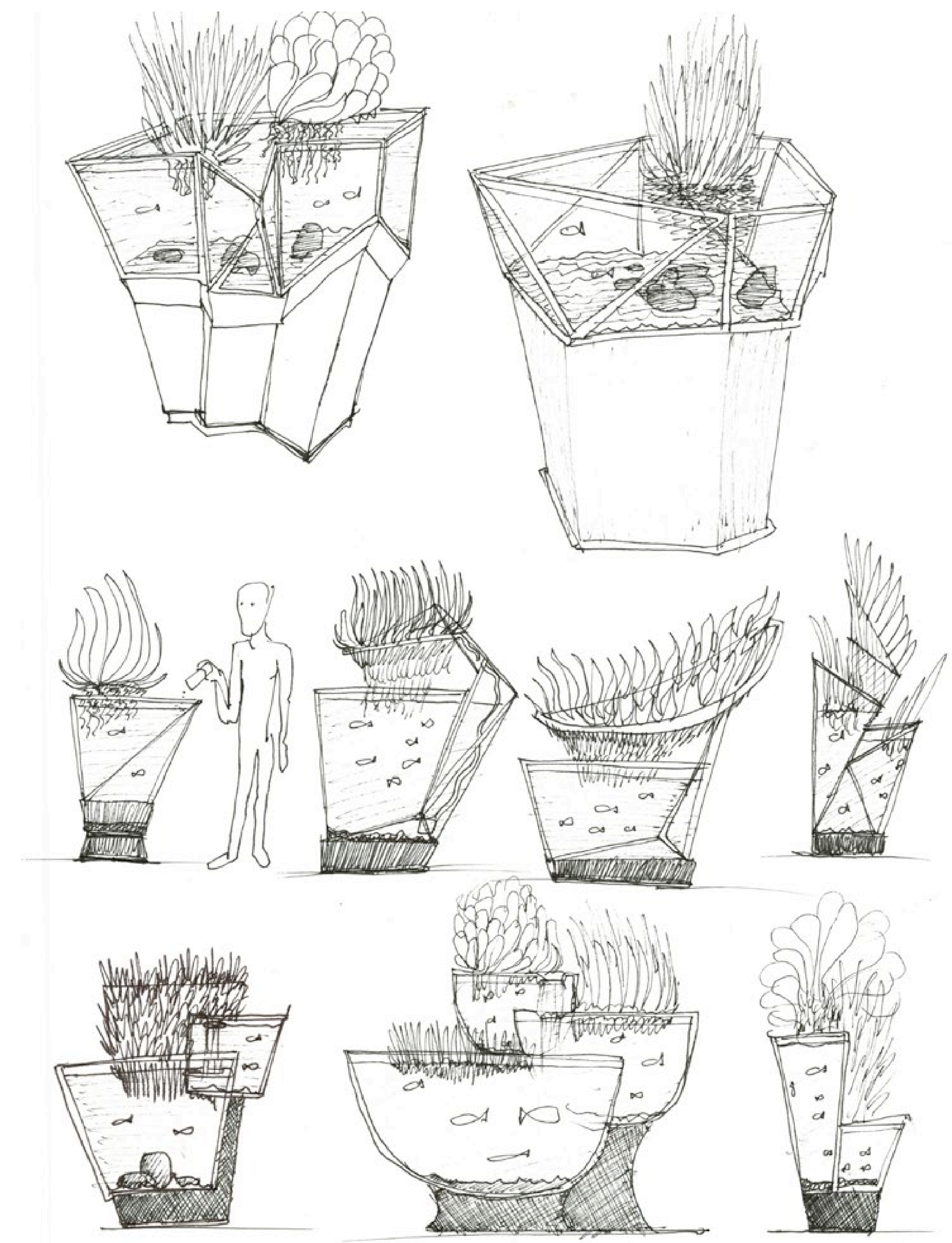

HUMANS + PLANTS
POTTED PLANTS + AQUARIUMS
LIFE ENGINE
CONCEPT PRESENTATION WALKTHROUGH
HOSPITAL STUDY
ENDER!
— STRESS RELIEF
— MENTAL HEALTH
— URBAN LIFESTYLE
— AIR QUALITY
HYDRO PONICS + AQUA CULTURE
AQUAPONICS
FISH
BACTERIA
ECOSYSTEM
PLANTS
STRUCTURE
MODULAR
EXPANSION TO FIT NEED
TROPHIC LEVELS
PUMPS + FANS + LIGHTS
DIGITAL - SENSORS, CAMERA, MICROSCOPE
OPTICAL - PRIZM, MAGNIFYING GLASS, FRESNEL, MIRR
INTERACTIONS
DAILY
WEEKLY
MONTHLY
YEARLY
GETTING YOUR HANDS DIRTY
SEEING LIFE GROW
FEEDING + CLEANING
EATING FOOD!
BREATHING FRESH AIR!
SEE LIFE MULTIPLY
SCALE: INDUSTRIAL FARMING AS REFERENCE
HOME-SIZED SYSTEMS ARE ON THE RISE
AQUAFARM
BLUE GREEN BOX
DIY - SETUPS
5-50 GALLONS
EXPERIENCE
REWARDING — GROWTH
EDUCATIONAL — BIOLOGY
NUTRITIOUS
SOOTHING - MENTAL HEALTH
FOOD
LOOKS
VEGGIES
TILAPIA
HERBS
PHYSICALLY TANGIBLE
BETA
FLOWERS
GRASS
BONSAI
FLASHY FISH
MENTALLY TANGIBLE
HOSPITAL STUDY
STRESS
"NATURE IS NOT A PLACE TO VISIT; IT IS HOME"
HUNTER + GATHERER
URBAN LIFESTYLE → STRESS
STRUCTURE
BALANCED SUPERORGANISM

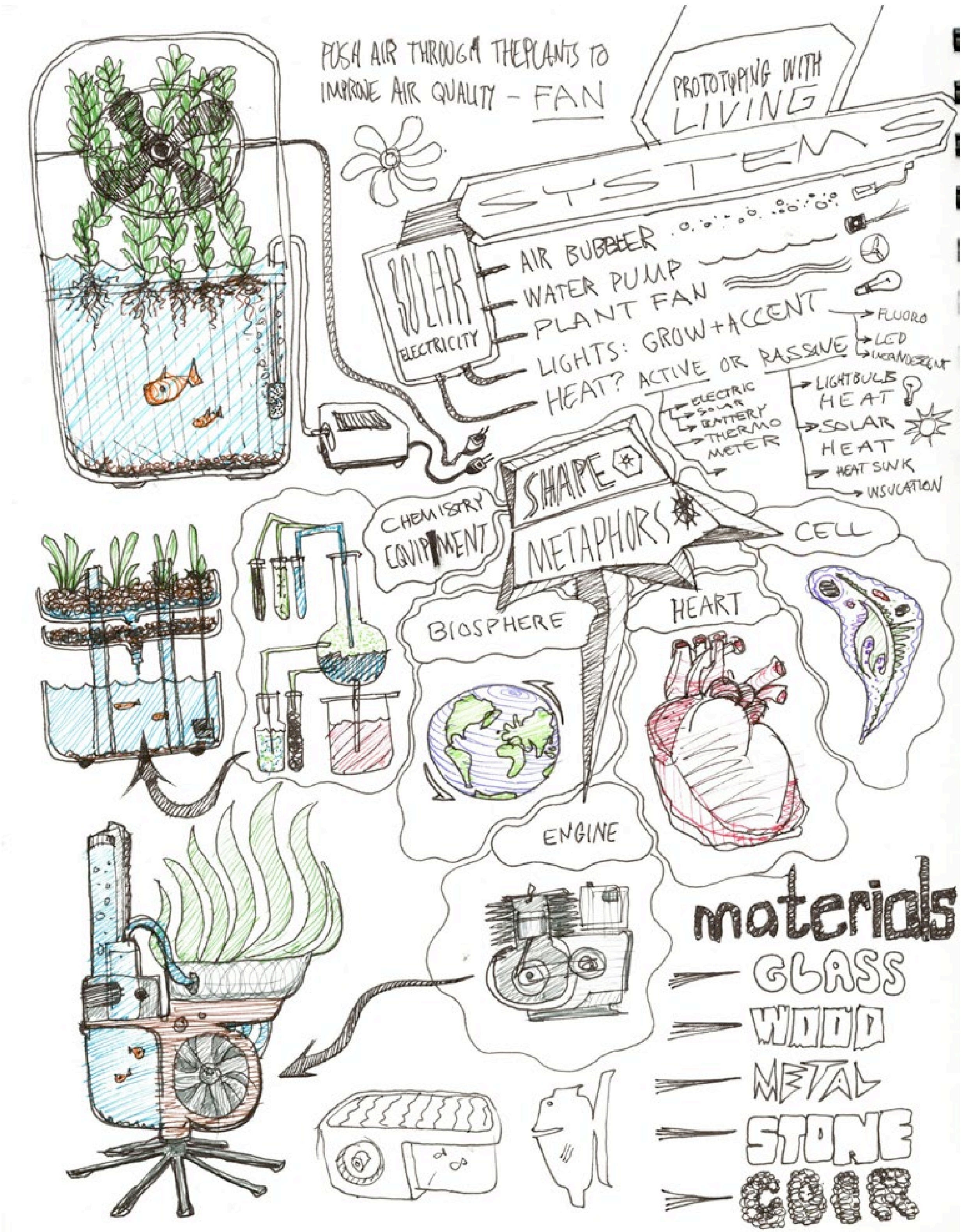

FLOWERS
FRUITS
VEGETABLES
HERBS
BONSAI
PLANTS
FISH
MOLLUSCS
SNAILS
ANIMALS
WORMS
CHICKENS
INSECTS
BACTERIA
AMONIA EATERS
NITRITES EATERS
NITRATES MAKERS
BITPONICS
AUTOMATIC HYDROPONIC GARDEN
— SENSORS SYNCED ONLINE
— APP "DASHBOARD" OF SENSORS
— 120v OUTLETS FOR AUTOMATING LIGHT TIMING / PUMPS SCHEDULE
— LOG DATA, EASILY TRANSLATED TO TRENDS - GRAPHS
— USE "GROW PLANS" - SHARE WITH OTHERS ONLINE!
VISUALIZES GOOD & BAD DAYS AND RELATES TO GROWTH
PH
LIGHT EXP.
AIR TEMP
HUMIDITY
WATER TEMP
NUTRIENT LEVELS?
AQUAFARM
AQUAPONIC MICRO-SIZED TABLETOP AQUARIUM
— COUNTER-TOP SIZE - 3 GALLON
— DECORATIVE FISH
— EDIBLE HERBS
— KITCHEN AS LOCATION!
BASIL + HERBS + GRASS
BETA FISH
BLUEGREEN BOX
— FITS ONTO EXISTING AQUARIUM

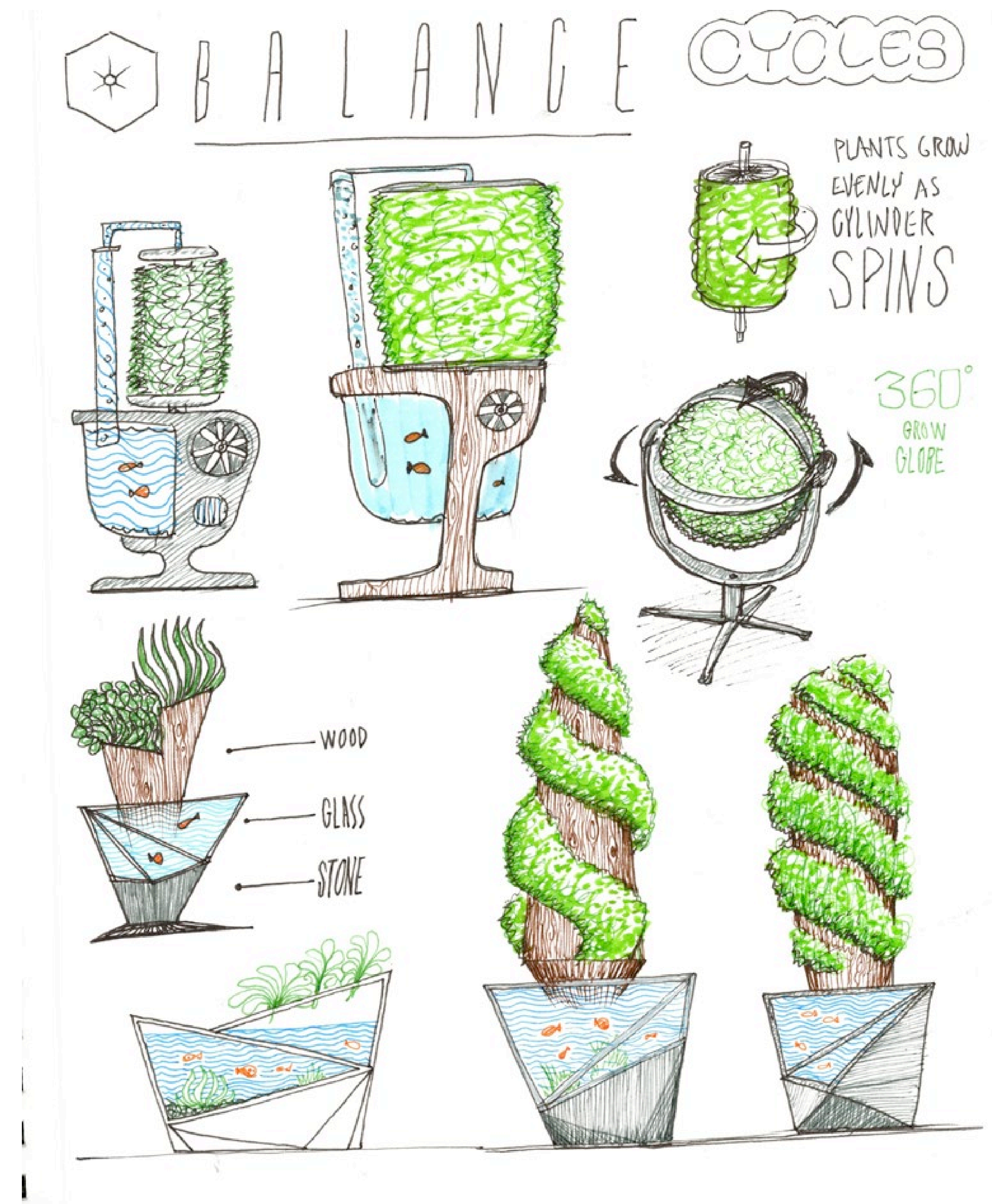

PARTS OF THE SYSTEM
HYDROPONIC
REARING TANK
SETTLING BASIN
BIO FILTER
SUMP
HYDROPONICS
SETTLING BASIN
BIOFILTER
REARING TANK
SUMP
AQUAPONICS
RHIZO FILTRATION
SIPHON DRAIN
DEEP-WATER RAFTS
RECIRCULATING AQUAPONICS
RECIPROCATING
TRICKLE-FED TOWERS
NUTRIENT FILM TECHNIQUE
FISH
PLANTS
BACTERIA
FUNGUS
INSECTS
SUN
AQUACULTURE
HYDROPONICS
PONICS

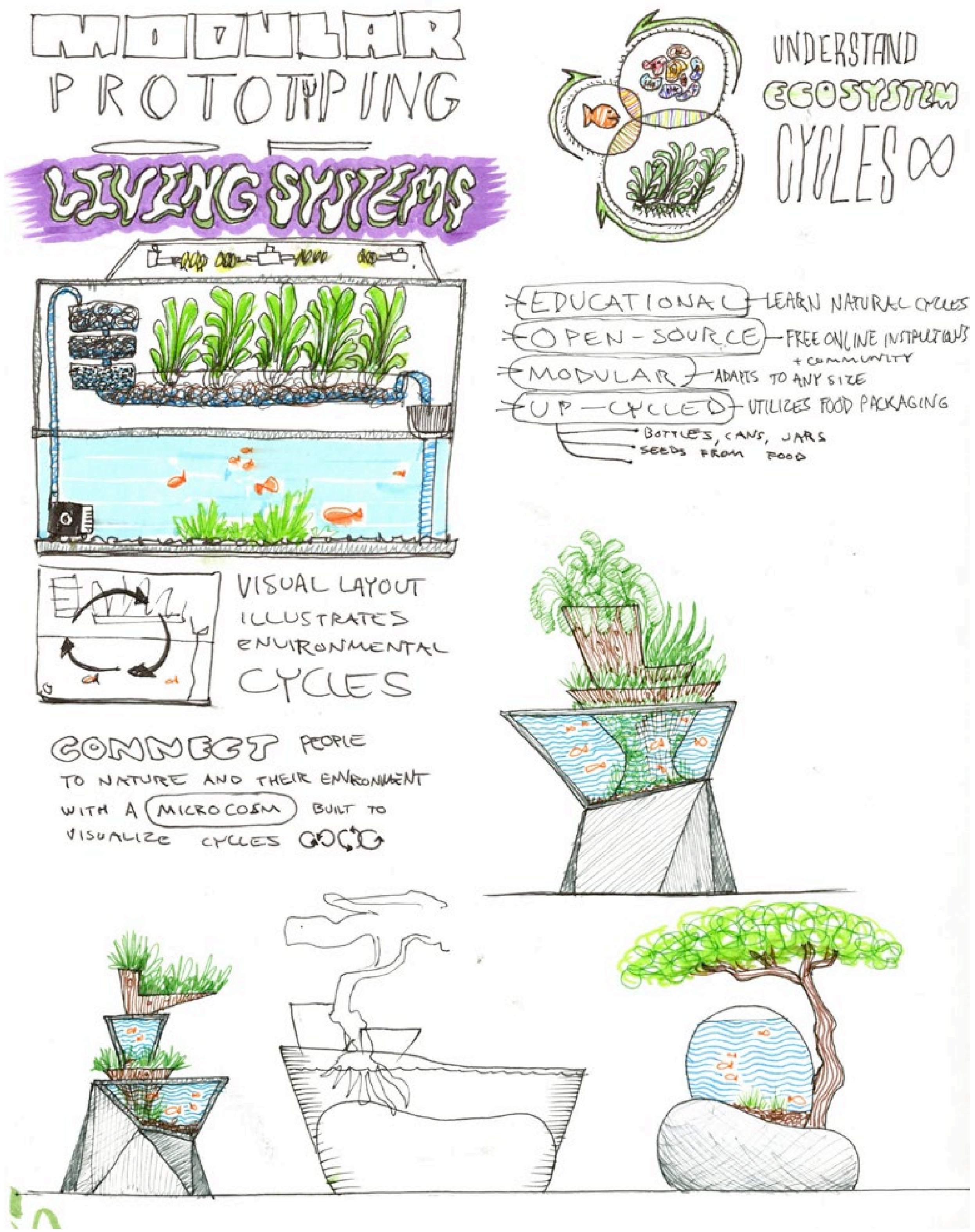

BIOCIRCLE
POWERED BY
CLOCKWORK MECHANICS
WIND UP COIL SPRING MOTOR
SUPPLIES NRG FOR PUMP
FAN, BUBBLER, FILTER
FOOD DELIVERY
TIME INTERVAL?
ONCE A DAY
ONCE A WEEK
SUSPENSION LINES
HYDROPONICS + AQUAPONICS + BIOFILTER
ARE MODULAR UNITS SUSPENDED IN A CIRCULAR FRAME + CONNECTED WITH TUBES
PUMP PUSHES WATER UP, GRAVITY BRINGS WATER DOWN THROUGH SYSTEM
UNITS
FRAME
INTERACTION VISIBILITY
LIKE CHEMISTRY EQUIPTMENT
SUSPENDED UNITS
COUNTER WEIGHT
LIFT WEIGHT UP
WEIGHT SLOWLY DESCENDS, POWERING FAN FOR SHORT INTERVAL
FAN
GRAVITY BATTERY

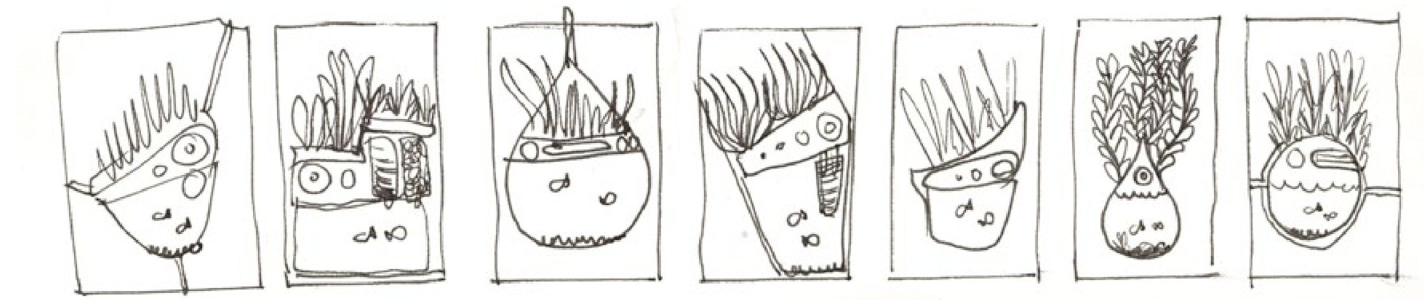

ACCENT LIGHTING
CYCLES
AQUAFARM KICKSTARTER
PROTOTYPING WITH LIVING SYSTEMS
WHAT IS A MEASURE OF SUCCESS?
(IN MY PROJECT)

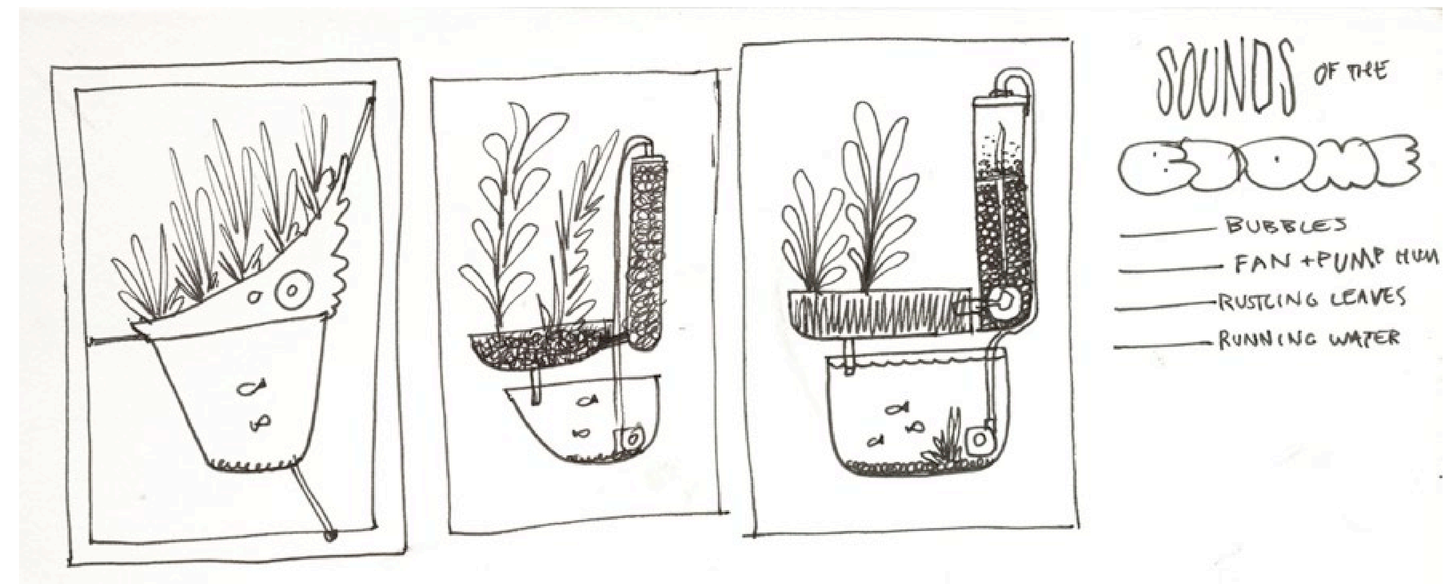



PUSH AIR THROUGH THE PLANTS TO IMPROVE AIR QUALITY - FAN
PROTOTYPING WITH LIVING
SYSTEMS
SOLAR ELECTRICITY
AIR BUBBLER
WATER PUMP
PLANT FAN
LIGHTS: GROW + ACCENT
FLUORO
LED
HEAT? ACTIVE OR PASSIVE
ELECTRIC
SOLAR
BATTERY
THERMO METER
LIGHTBULB HEAT
SOLAR HEAT
HEAT SINK
INSULATION
SHAPE METAPHORS
CHEMISTRY EQUIPMENT
CELL
BIOSPHERE
HEART
ENGINE
materials
GLASS
WOOD
METAL
STONE


BALANCE
CYCLES
PLANTS GROW EVENLY AS CYLINDER SPINS
360°
GROW GLOBE
WOOD
GLASS
STONE


MODULAR
PROTOTYPING
LIVING SYSTEMS
UNDERSTAND
ECOSYSTEM
CYCLES ∞
EDUCATIONAL — LEARN NATURAL CYCLES
OPEN-SOURCE — FREE ONLINE INSTRUCTIONS + COMMUNITY
MODULAR — ADAPTS TO ANY SIZE
UP-CYCLED — UTILIZES FOOD PACKAGING
BOTTLES, CANS, JARS
SEEDS FROM FOOD
VISUAL LAYOUT ILLUSTRATES ENVIRONMENTAL CYCLES
CONNECT PEOPLE TO NATURE AND THEIR ENVIRONMENT WITH A MICROCOSM BUILT TO VISUALIZE CYCLES




SOUNDS OF THE
BUBBLES
FAN + PUMP HUM
RUSTLING LEAVES
RUNNING WATER

APPENDIX B: SCHEDULE

November 2013

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

Fri 22: Final Research Report
Post Final Research Report on Blog
Thurs 28: Presentation Deliverables
Fri 29: Final Concept Presentation

December 2013

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

Fri 10: Preliminary design sketches & issues
Wed 25: Christmas Day

January 2014

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

Wed 22: Looks & works like prototypes
Wed 29: Technical drawings
Thurs 30: Preliminary boards with issues
Fri 31: Preliminary design review
Post design on blog

February 2014

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	

Mon 3: Make design posters
Wed 5: Edit & print posters
Thurs 6: Poser & presentation set up
Fri 7: Prototype presentation
Fri 21: General Arrangement updated
Fri 28: Use scenario boards

March 2014

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

Mon 3: Renderings
Wed 5: Bill of Materials
Thurs 6: Definitive design review due
Fri 7: Definitive design review presentation
Mon 31: Power point for final presentation

April 2014

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30			

Wed 2: Final presentation deliverables
Thurs 3: Final presentation
Fri 4: Final presentation
Fri 25: Final Project Report
Electronic copies of materials

Background Image (Layers of Learning, n.d.)

Works Cited

"About Us." Spark Truck. N.p., 2012. Web. 21 Nov. 2013. http://sparktruck.org/about.

Allan, Alasdair. "Which Board Is Right for Me?" MAKE. N.p., 27 Sep. 2013. Web. 20 Nov. 2013. http://makezine.com/magazine/make-36-boards/which-board-is-right-for-me/.

Amano, Takashi. Portfolio Website. 2013. www.amanotakashi.net.

Anderson, Chris. "20 Years of Wired: Maker Movement." Wired. N.p., 2 May 2013. Web. 20 Nov. 2013. http://www.wired.co.uk/magazine/archive/2013/06/feature-20-years-of-wired/maker-movement.

Aquafarm. Back to the Roots Company Website. 2013. https://backtotheroots.com/shop/aquafarm.

Barton, Susan. Human Benefits of Green Spaces. University of Delaware Botanical Garden. 2009.

Beale, Scott. "Maker Faire Bay Area 2008." flickr. N.p., 4 May 2008. Web. 21 Nov. 2013. http://www.flickr.com/photos/laughingsquid/2471711676/.

Benyus, Janine. 2002. Biomimicry: Innovation Inspired by Nature. Avon; 1 edition, 2002.

Benyus, Janine (June 2013) The 3D printing Revolution Explained in 20 Minutes. Accessed: November 10, 2013, http://biomimicry.net/videos/2013/the-3d-printing-revolution-explained-in-20-minutes/.

BitPonics. Bitponics Company Website. 2013. http://www.bitponics.com/.

Bjerede, Marie. "Tinkering with Technology Education." O'Reilly Radar. N.p., 6 June 2011. Web. 20 Nov. 2013. http://radar.oreilly.com/2011/06/education-maker-technology.html.

Brynildsen, Jens "Maker Faire Oslo" Flashgamer. N.p., 29 Apr. 2013. Web. 22 Nov. 2013. http://flashgamer.com/arduino/comments/maker-faire-oslo.

"Calling All Makers...." Dublin Mini Maker Faire. N.p., 2012. Web. 21 Nov. 2013. http://www.makerfairedublin.com/calling-makers/.

Cole, Ian. "Miami Mini Maker Faire 2013." MAKE. N.p., 16 Nov. 2013. Web. 21 Nov. 2013. http://makezine.com/2013/11/16/miami-mini-maker-faire-2013/.

Cole, Ian. "The Maker Movement." Raising Geeks. N.p., 2011. Web. 20 Nov. 2013. http://www.raisinggeeks.com/blog/maker-movement/.

"Computer Lab." Teleread. N.p., 14 Jan. 2013. Web. 22 Nov. 2013. http://www.teleread.com/wp-content/uploads/2013/01/Computer_Lab.jpeg.

"Defining Maker." Haystakt. N.p., 22 Aug. 2013. Web. 21 Nov. 2013. http://www.haystakt.com/journal/article_view/15/Editorial/3#.Uo9iyuIlinP.

Del Laet, Lars. 2008. Tensile structures: Do it yourself. Accessed on November 2, 2013, http://fabricarchitecturemag.com/articles/0708_f3_tensile.html.

Ecotech Marine. Company Website. 2013. http://ecotechmarine.com/.

Flavelle, Dana. "Decoding Canada's 'skills crisis': What's the solution?." Toronto Star. http://

www.thestar.com/business/2013/05/31/decoding_canadas_skills_crisis_whats_the_solution.html.

Fuller, Buckminster. Operating Manual for Spaceship Earth. 1968.

Giridharadas, Anand. "The Kitchen-Table Industrialists." The New York Times. N.p., 12 May 2011. Web. 21 Nov. 2013. http://www.nytimes.com/2011/05/15/magazine/the-kitchen-table-industrialists.html?pagewanted=all&_r=0.

Haeckel Bowl in Salt. 2013. Accessed on September 28, 2013, http://www.emergingobjects.com/projects/haeckel-bowl-in-salt/.

Harman, Jay. 2013 The Shark's Paintbrush: Biomimicry and How Nature is Inspiring Innovation. White Cloud Press (2013)

Hickman, Matt. "Go Ahead, Marker Faire My Day." Mother nature network. N.p., 19 Sep. 2011. Web. 21 Nov. 2013. http://www.mnn.com/your-home/at-home/blogs/go-ahead-maker-faire-my-day.

Hod, Lipson. Kurman, Melba. 2013. Fabricated: The New World of 3D Printing. Wiley, 2013.

Howard, Brian, 2013. Improving 3D Printing by Copying Nature. Accessed on November 10, 2013. http://news.nationalgeographic.com/news/2013/07/130707-3d-printing-biomimicry-green-design-science/.

Human Anatomy, 2010. Synovial Joints. Accessed: November 1, 2013, http://www.mananatomy.com/basic-anatomy/synovial-joints.

Ideastream. 2013 3D Casts So Coll That You'll Almost Want To Break A Bone. Accessed on: September 23, 2013 http://www.ideastream.org/news/npr/200125266.

"Inside the Spark Truck." flikr. SparkTruck, 13 Oct. 2012. Web. 21 Nov. 2013. http://www.flickr.com/photos/sparktruck/8347456258/.

La Fleche, Gersande. "Is Computer Programming the New Literacy?" The McGill Daily. N.p., 16 Sep. 2013. Web. 12 Nov. 2013. http://www.mcgilldaily.com/2013/09/is-computer-programming-the-new-literacy/.

Libow Martinez, Sylvia, and Gary Stager. "Why the Maker Movement matters to educators."

SmartBlogs. http://smartblogs.com/education/2013/08/20/why-the-maker-movement-matters/.

Liu, David. "Is Education Killing Creativity in the New Economy?" Fast Company. N.p., 26 Apr. 2013. Web. 16 Nov. 2013. http://www.fastcompany.com/3008800/education-killing-creativity-new-economy.

Marcus, Clare Cooper. Gardens in Healthcare Facilities. The Center for Health Design Inc. 1995.

Marino, Jonathan "Another Project for the Maker Revolution: Making History." Distilled. N.p., 8 May 2013. Web. 20 Nov. 2013. http://distilledmagazine.com/another-project-for-the-maker-revolution-making-history/.

Martel, Alexandre. "L'évènement Maker-Faire Débarque En France Les 11 Et 12 Octobre Prochains!" 3Dnatives. N.p., 2 Sep. 2013. Web. 20 Nov. 2013. http://www.3dnatives.com/levenement-maker-faire-debarque-en-france-les-11-et-12-octobre-prochains/.

Marzouk, Sharon. "Classroom Robotics: Motivating Independant Learning and Discovery." Robohub. N.p., 3 Oct. 2013. Web. 21 Nov. 2013. http://robohub.org/classroom-robotics-motivating-independent-learning-and-discovery/.

McClung, Dennis. Garden Pool Non-profit Website. 2013. www.gardenpool.org.

McDonough, Williams & Braungart, Michael. Cradle to Cradle. North Point Press. 2002.

Medical Dictionary. Joints: Various Kinds of Joints. Retrieved from: http://medical-dictionary.thefreedictionary.com/Chopart's+joint.

Meyers, Marc. McKittrick, Joanna. 2013. Tough, Light and Strong: Lessons from Nature Could Lead to the Creation of New Materials. Accessed: November 1, 2013, http://www.sciencedaily.com/releases/2013/02/130214141800.htm.

Perkins + Will. 2013. Accessed on November 19, 2013, http://www.perkinswill.com/work/architecture.html.

Pfaffenberger, Bryan. Fetishized Objects and Humanized Nature: Towards an Anthropology of Technology. Royal Anthropological Institute of Great Britain & Ireland, 1988.

Price, Charlie. Aquaponics: Getting More out of Less. TED Talks. 2011. http://www.youtube.com/watch?v=7nIL9hWW3-Q.

Robinson, Ken. "Ken Robinson: How to escape education's death valley." YouTube. http://

www.youtube.com/watch?v=wX78iKhInsc .

Rogers Communications. "High School Drop Out Statistics|The Facts About Education." Rogers

Youth Fund. http://www.rogersyouthfund.com/the-facts.html.

Rothberg, Deborah. "10 Programming Languages You Should Learn Right Now." eWeek. N.p., 15 Sep. 2006. Web. 7 Nov. 2013. http://www.eweek.com/c/a/IT-Management/10-Programming-Languages-You-Should-Learn-Right-Now/.

Rutgers n.d. Types of Synovial Joints n.d. Accessed on November 11, 2013, http://www.rci.rutgers.edu/~uzwiak/AnatPhys/APFallLect11.html.

Works Cited

"School Visits." Southfield Institute. N.p., 23 Oct. 2013. Web. 22 Nov. 2013. http://southfieldinstitute.com/wp-content/uploads/2013/10/staten-island-school.jpg.

Shapeways Blog, 2013. How to Design Snap-Fit Ball Joints for 3D Printing with Shapeways. Accessed: November 12, 2013. http://www.shapeways.com/blog/archives/2238-how-to-design-snap-fit-ball-joints-for-3d-printing-with-shapeways.html.

Smith|Allen. 2013. Echoviren. Accessed on October 25, 2013, http://www.archdaily.com/419306/echoviren-smith-allen/.

Stangler, Dane. "Do It Yourself: Creating a Producer Society." Progressive Policy Institute. N.p., 12 Sep. 2011. Web. 21 Nov. 2013. http://www.progressivepolicy.org/2011/09/do-it-yourself-creating-a-producer-society/.

"Stem to Steam," STEM to STEAM, 2013, accessed October 11, 2013, http://stemtosteam.org/.

"The Basics: How Programming Works." Microsoft Developer Network. Microsoft, 2008. Web. 16 Nov. 2013. http://msdn.microsoft.com/en-us/library/ms172579%28v=vs.90%29.aspx.

"The Benefits of Self-Directed Learning," Alternatives to Schools, September 29, 2013, accessed

October 11, 2013, http://alternativestoschool.com/benefits-self-directed-learning/.

Todd, John + Nancy. From Eco-Cities to Living Machines: Principles of Ecological Design. North Atlantic Books, 1993.

University of California Museum of Paleontology (UCMP). n.d Radiolaria: More on Morphology. Accessed on October 20, 2013. http://www.ucmp.berkeley.edu/protista/radiolaria/radmm.html.

Walker, Stuart. Object lessons: Enduring artifacts and sustainable solutions. MIT 2005.

Wente, Margaret, "Who's Failing Math? the System," Globe and Mail, September 05, 2013,

accessed October 11, 2013, http://www.theglobeandmail.com/commentary/whos-failing-math-thesystem/article14112165/.

"What Is Computer Programming?" Berkeley Foundation for Opportunities in Information Technology. N.p., 2007. Web. 7 Nov. 2013. http://www.bfoit.org/Intro_to_Programming/Programming.html.

Wholman. "Scrap Adirondack Chair." Instructables. N.p., 2012. Web. 20 Nov. 2013. http://www.instructables.com/id/Scrap-Adirondack-Chair/.

Wilson, Edward O. Future of Life. Vintage publishing. 2002.

THANK YOU