The Philosophy and Practice of Academic Makerspaces

Vincent Wilczynski
Moshe Kam
Daniel Brateris

4 April 2017
A word on the development of this session

The existing NJIT Makerspace
A word on the development of this session

The existing NJIT Makerspace
The New NJIT Makerspace
Yale Center for Engineering Innovation and Design (CEID)
academic makerspaces
 motivation
 history
 types
 examples
academic makerspaces

motivation

history

types

examples
making (engineering) is trending
NATION OF MAKERS
Announcing a Week of Making this June 12-18
A Nation Of Makers
Find maker schools
Explore 40 institutions and their people, projects, spaces and courses.

Boise State University
Boise, Idaho
http://www.boisestate.edu/
@boisestatelive

Carnegie Mellon University
Pittsburgh, Pennsylvania
http://cmu.edu
@CarnegieMellon

makeschools.org
making origins:

engineering

as

building
engineering as calculating
engineering as design
engineering
as
making
makerspace programming

learn
- workshops
- training
- courses

make
- open studio
- club support
- summer fellowships

share
- social events
- networking & career events
- lectures

informal  ⟷  formal
academic makerspaces
motivation
history
types
examples
maker
history
BASIC Stamp 1995

Arduino 2005

Raspberry Pi 2012
NEWS: ChiefDelphi.com gets a facelift, slowly but surely. Over the next few weeks, each section will be converted to the new look, leaving the forums and poll section until the end of December.

ALUMNI What are our alumni up to? See here.
POLS Chief Delphi Polls. Voice Your Opinion!
FORUMS Our famous discussion forums. Share your thoughts here.
COMPETITION See results from the competitions.
HISTORY A bit about our team.
GALLERY Thumbnailed pictures of robots.
WHITE PAPERS Publish your thoughts.
# Higher Education Makerspace Initiative (HEMI)

**2017: 150+ Higher Education Makerspaces**

### ASEE Conference “makerspace” keyword:

- **2014**: 1
- **2015**: 22
- **2016**: 49

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## ISAM 2016

**International Symposium on Academic Makerspaces**

1st International Symposium on Academic Makerspaces

ISAM is a collaborative effort of the Higher Education Makerspace Initiative (hemi.mit.edu)

ISAM 2016 was held November 13th-16th, 2016

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### Recent News

- **Applications for MERSI due**
  - Friday, March 24
  - Fri, 03/10/2017

- **Announcing Makerspace Technology Professional Course**
  - Wed, 02/22/2017

- **Intro to Making Course 15.550 - Spring 2017**
  - Fri, 01/13/2017

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### Contact Us

**Project Manus Central Office**

Room 35-237
77 Massachusetts Avenue
Cambridge, MA 02139

For Mobius, email:

jhunt@mit.edu

Everything else

email: saana@mit.edu

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**Berkeley University of California**
**Carnegie Mellon University**
**Case Western Reserve University**
**Georgia Tech**
**MIT**
**Olin College of Engineering**
**Stanford University**
**Yale**
academic makerspaces
motivation
history
types
examples
types of academic makerspaces

- course focus
- project (personal/club) focus
- community focus
makerspace characteristics

accessibility:
courses, department, school or university

programming

management & staffing:
student, faculty/professionals or hybrid model

# of users:
10, 100, 1,000 or more

size:
100, 1,000, 10,000 or more sqft
makerspace culture
learning space
community
collaborative
supportive / forgiving
makerspace culture

low barrier to initial entry

trust (in students)

transparent policies

a culture of safety
academic makerspaces
motivation
history
types
examples
virtual tour of academic makerspaces

Massachusetts Institute of Technology
Stanford University
Georgia Institute of Technology
Northwestern University
Rice University
ASU/TechShop (Chandler, AZ)
Yale University
Massachusetts Institute of Technology
Pappalardo Lab (20,000 sqft)
Massachusetts Institute of Technology
Pappalardo Lab (20,000 sqft)
Massachusetts Institute of Technology
MITERS (1,000 sqft)
Stanford University
Product Realization Lab (2,000 sqft)
Stanford University
d-school (24,000 sqft)
Georgia Institute of Technology
Invention Studio (3,000 sqft)
Northwestern University
Segal Design Institute (20,000 sqft)
Rice University
Oshman Eng. Design Kitchen (18K sqft)
Arizona State University
Chandler Tech Shop (35,000 sqft)

who  Full-time ASU students (valid student ID required)
what  FREE membership to TechShop and $100 in TechShop classes
when  Starting September 2, 2014
where  ASU Chandler Innovation Center
        249 E. Chicago St. Chandler, AZ 85225
        (480) 327-0820  l  info.ch@techshop.com

New to making? No problem, TechShop will train you on prototyping equipment and tools.

www.techshop.com
Arizona State University
Chandler Tech Shop (35,000 sqft)
Arizona State University
Chandler Tech Shop (35,000 sqft)
Yale University - Center for Eng. Innovation & Design (8,500 sqft)
Yale CEID membership

2,000 current members

~15% of all Yale students are members
~20% of all Yale undergrads are members
unique attributes

**MIT Pappalardo Lab:** 150+ person per semester training/certification program

**MIT MITERS:** student organization

**Stanford PDL:** primarily serves multiple departmental courses

**Stanford d-school:** focuses on “innovators not innovation”
unique attributes

**GA Tech:** primarily student-run

**Northwestern:** interdisciplinary academic unit that grants degrees

**Rice:** diverse population of eng, mat sci, applied math, & CS users

**ASU:** public/private partnership

**Yale:** open to entire university
observations

academic makerspace mission must be clearly defined, with space built around that mission

community is key

it takes (some) work to establish a maker community on campus
observations

open environments promote collaboration

staffing is essential

align access times with student work schedules

user training is mandatory
academic makerspaces

motivation

history

types

examples
The Role of the Makerspace in Academic Education

Vincent Wilczynski
Moshe Kam
Dan Brateris

4 April 2017
The Makerspace on the Education Theory Spectrum
The Makerspace on the Education Theory Spectrum

**Constructivism**
- **Benefits:** Experiences are real, and curricular development is child-centered, promoting higher-order thinking.
- **Problems:** Can be challenging, especially for students who are not ready for advanced concepts.

**Behaviorism**
- **Benefits:** Learning is based on classical conditioning.
- **Problems:** Does not promote higher-level thinking and may not cater to all learners.

**Cognitivism**
- **Benefits:** Learning is based on information processing.
- **Problems:** Ineffective when higher-level thinking is required.

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**ASEE**
**NJIT**
**Yale**
Behaviorism

... assumes a learner is essentially passive, responding to environmental stimuli

The learner starts off as a clean slate (i.e. tabula rasa)

Behavior is shaped through positive reinforcement or negative reinforcement
Cognitivism

...focuses on the inner mental activities – opening the “black box” of the human mind is valuable and necessary for understanding how people learn

Mental processes such as thinking, memory, knowing, and problem-solving need to be explored

Knowledge can be seen as schema or symbolic mental constructions. Learning is defined as change in a learner’s schemata.
Constructivism

**Constructivism**

- Knowledge is constructed based on personal experiences and hypotheses of the environment.
- Learners continuously test these hypotheses through social negotiation.
- Each person has a different interpretation and construction of knowledge process.
- The learner is not a blank slate but brings past experiences and cultural factors to a situation.

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**Behaviorism**

- **KEY CONCEPT: Theory of Behavior**
- **Elements of Learning**
  - Stimulus/Response
  - Programmed Instruction
  - Direct Instruction
- **Key Plan: Programmed Learning**
  - Break material into series of units (chunking)

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**Cognitivism**

- **Key Concept: Cognitive Theory**
- **Elements of Learning**
  - Knowledge of how students learn
- **Key Plan: Constructivist Learning**
  - Learners construct their own learning environment

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...learning is an active, contextualized process of constructing knowledge rather than acquiring it
The Maker Movement in education aims to cause a shift away from ready-made knowledge to a classroom environment ripe for exploration, creativity, innovation and collaboration with hands-on materials and real world problems.

At the heart of this movement is the understanding that “learning happens best when learners construct their understanding through a process of constructing things to share with others”

DIY vs. DIWO
Innovation and creativity are the principal learning outcomes.
The Desired Outcome

• …have learners create their own knowledge by creating and interacting with physical objects.
  – connections to media literacy and self-directed learning

• “Ultimately, the outcome of maker education and educational makerspaces leads to determination, independence and creative problem solving, and an authentic preparation for the real world through simulating real-world challenges”

• “…an educational makerspace is less of a classroom and more of a motivational speech without words” (Kurti et al., 2014, p. 11).

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• “Ultimately, the outcome of maker education and educational makerspaces leads to determination, independence and creative problem solving, and an authentic preparation for the real world through simulating real-world challenges”

• “…an educational makerspace is less of a classroom and more of a motivational speech without words” (Kurti et al., 2014, p. 11).

• Innovation and creativity are the principal learning outcomes
“Unless educators intentionally pursue innovation and creativity as learning outcomes, makerspaces will become “imagination ghettos” where issues of access, purpose, and ownership resemble those common in the cloistered environments of early computer labs and many of today’s shops, where students are tasked with cookie cutter activities and trivial projects to complete.”

(Crichton & Carter, 2015, p. 3).
What is available? (1)

- Design software
  - Provides intuitive interfaces to perform design tasks that used to require topical expertise
- Manufacturing tools
- Integrated control systems
  - Hand Tools and Power Tools
  - 3D printers
  - Laser, water and plasma cutters
  - Computer controlled mills, lathes, routers
  - Equipped suites for woodwork, metalwork and electronics
- Raw materials
What is available? (2)

- Professional guidance and supervision
- Virtual Library
  - Some Makerspaces became a ‘branch’ of the school library
  - Project library, documentation and schematics
- Meeting Spaces
  - Near the work space
  - Yet quiet and accommodating
- Storage
  - Student projects
  - Material
  - Tools

Center for Social Innovation
New York City
- Experimentation
- Enhancement of instruction
  - Simulations, emulations and models
- Re-enactment of classical experiments

Classroom and lab

Makerspace
Enhancement of Instruction (1)

- Use of the Makerspace to supplement other class and lab experiences
  - Build molecular models
  - Build models of body parts (e.g., joints)
  - Wide use of robotic systems and subsystems
    - Locomotion
    - Self location
    - Navigation
    - Sensors
    - Sensor Fusion
Enhancement of Instruction (2)

- Prototyping
- Urban modeling
- Drone design
- Modeling of historical machines and inventions

Historical Water Wheels
Makerspace

Self-growth and awareness

- Entrepreneurship
- Teams: opportunities to lead and follow
- Self-directed projects; nonprescriptive project development
- Development of productive work habits
- Multi-term multi-year design

Design Experience
- Student skill development
  - E.g., experience with machinery and equipment
- Opportunities to engage
  - with the Makerspace and students
- Experimentation
- Enhancement of instruction
  - Simulations, emulations and models
  - Re-enactment of classical experiments

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Classroom and lab

Makerspace

Industry

Self-growth and awareness

Design Experience

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- Self-directed projects; nonprescriptive project development
- Development of productive work habits
- Multi-term multi-year design
Integration and Access

- Makerspaces combine the traditional machine shop, CAD lab, library, classroom and meeting space into one integrated facility

- Encourage diverse groups of problem solvers
  - Sharing space: proximity breeds collaboration

- Broad Access to students, staff and faculty from all disciplines
  - Open access
    - Training-dependent access
  - Subscription model
    - Various models for recovery of cost of material

- Some facilities open or are accessible 24/7
  - Possibly with reduced access to heavy machinery in off-peak hours
Compatibility with existing goals and criteria

ABET student outcomes

• (a) an ability to apply knowledge of mathematics, science, and engineering
• (b) an ability to design and conduct experiments, as well as to analyze and interpret data
• (c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
• (d) an ability to function on multidisciplinary teams
• (e) an ability to identify, formulate, and solve engineering problems
• (g) an ability to communicate effectively
• (k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.
ABET Criterion 5: Engineering Design

• (b) One and one-half years of engineering topics, consisting of engineering sciences and engineering design appropriate to the student’s field of study…Engineering design is the process of devising a system, component, or process to meet desired needs. It is a decision-making process (often iterative), in which the basic sciences, mathematics, and the engineering sciences are applied to convert resources optimally to meet these stated needs.
Contributions to the student design experience

- Support of traditional design experiences
  - First-year and last-year design projects

- Support of design “every year, every term”
  - Enables multi-year design experiences with semi-permanent teams

- Support of design by student groups in the community
  - Variants of the EPICS project
    - Engineering Design in Community Service

- Competition support

- Support of self-directed design
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• Support of self-directed design
Maker Faire Somerville
Hexapod Robot

GCAA Makerspace

NJIT

Minddrive KC
Support for heterogeneous teams

• Design teams across Departments and across Colleges
  – Many Makerspaces are housed in the Mechanical Engineering Department
  – Increasingly, Makerspaces serve all Engineering and Science students
    • And in a number of institutions ALL students
  – We observed teams with students from Engineering, Business, Music, the Sciences (Biology, Physics, Mathematics), Architecture and Design

• Some Makerspaces serve students from adjacent institutions
  – MoA between schools or a subscription models
    • Example – NJIT and Rutgers-Newark and Essex Community College
“External” Groups

- Some Makerspaces serve adjacent high schools (teachers and students)
  - The Makerspace can be a recruiting tool
  - Requirements on hosting under-18 students can be challenging

- Some Makerspaces provide access to area small businesses and hobbyists
  - E.g., during off-peak hours, fee-based

- Some Makerspaces operate machinery on consignment from area corporations under shared-use agreements

Middle and high school students build a robot on University of Massachusetts, Amherst campus
Developing leadership skills

- In several schools the Makerspace is student run

A Review of University Maker Spaces, Barrett et al., ASEE, 2015
Training and Certification

• Safety
  • An opportunity to instill good work habits
    – Operating procedures, record keeping, lab notebooks
    – Elements of project management
  
• Equipment training
  – Basic training for general access
  – Training on specific machinery with additional access privileges

• Training on specific technologies, procedures and applications
  – Including user-initiated training

• Seminars and workshops on ongoing or planned projects
  – Including recruiting campaigns
Enabling student-driven entrepreneurship

• In most institutions, research initiatives and entrepreneurship were the domain of faculty and graduate students
  – New research initiatives often required high-level institutional support

• The maker culture and availability of Makerspaces encourage initiation of research by student groups
  – A bottom-up approach sometimes coupled with availability of nearby incubators
You give the roots, we give the wings.

"There are only two lasting bequests we can hope to give our children. One of these is roots, the other, wings." - Henry Ward Beecher
ADMINISTERING A GROUP OF DESIGN PROJECTS UNDER A COMMON THEME
3D Printing for Healthcare

- Create instructional tools such as 3D models of molecules or human anatomy that students can touch and handle
  - improve classroom instruction and expedite a student’s learning process

- Quickly prototype a physical model of a medical or healthcare-related invention
  - test out the feasibility of further entrepreneurial pursuit, commercialization, and mass production

- 3D scan and 3D print the exact bone structure of a specific patient to perform the best surgery
Design of Musical Instruments

Cal Poly

Drexel University

Northampton Community College

University of Washington

ASEE

NJIT

Yale
Wearable Electronics

LilyPad Arduino is connected to a Bluetooth Mate Silver

Conductive materials for wearable electronics
Informal Education: the IEEE Wing in the Birla Science Museum in Hyderabad
Informal Education: the IEEE Wing in the Birla Science Museum in Hyderabad
Re-enactment of the First Millimeter-wave Communication Experiments by J.C. Bose, 1894-96
A Few Caveats and Concerns

- Practical concerns
  - Safety
  - Proper use
    - Protecting the equipment
    - Preventing proscribed use
  - Control of resources
    - Materials
    - Tools
When it does not work…

“Unless educators intentionally pursue innovation and creativity as learning outcomes, makerspaces will become “imagination ghettos” where issues of access, purpose, and ownership resemble those common in the cloistered environments of early computer labs and many of today’s shops and students are tasked with cookie cutter activities and trivial projects to complete.”

(Crichton & Carter, 2015, p. 3).
Summary of Opportunities (1)

- Enhancing design experience of students
  - Including self directed

- Providing non-prescriptive design experience
  - A new face for engineering on campus

- Supporting entrepreneurship

- Providing platforms for innovation and expressing originality
  - Meeting spaces for students who wish to collaborate

- Enhancing team work and multidisciplinary collaboration

- Acquainting students with State of the Art machinery
Summary of Opportunities (2)

• Acquainting students with elements of manufacturing

• An opportunity to attract pre-university students to engineering programs

• A new avenue to cooperate with industry

• An opportunity to interest new donors in supporting the university

• Excitement and fun
The New NJIT Makerspace
The Logistics and Implementation of Academic Makerspaces

Vincent Wilczynski
Moshe Kam
Daniel Brateris
4 April 2017
Overview

• Review the Key Functions of Academic Makerspaces
• Space Layout
• Staffing and Operation
• Access
• Safety and Training
• Scheduling
• Use of Tools
• Machinery
• Storage
• Cost of Operation and Usage
There is no single way to operate a Makerspace facility

Every space is unique

Operation and design depend on many factors
Higher Education Makerspace Initiative (HEMI)

- The Higher Education Makerspaces Initiatives (HEMI) is a collaborative of leading universities focused on solving the challenges of academic makerspaces and making their combined learnings available to others.

http://hemi.mit.edu
Key Functions of Academic Makerspaces

• Build a community of learning and making
• Encourage students to design, prototype, build, and test
• Support design focused course work
• Encourage entrepreneurship
Space Needs

• Support Community, Design, Coursework, and Entrepreneurship

• To do this spaces need:
  – Safety!
  – Proper size
  – Staffing
  – Training
  – Accessibility
  – Resources
    • Tools and Equipment
    • Supplies
    • Storage
    • Resource management
Space Considerations

• Focus on creating areas for:
  – **Collaborative Workspace**: Collaboration, assembly, team work
  – **Fabrication Space**: Machinery, tools, material
  – **Design and Meeting Space**: Tables, white boards, projection…
  – **Instruction Space**: Typical classroom environment
Space Considerations

• Build spaces that are open and collaborative
• Many spaces use lots of glass
  – Aids in supervision
  – Builds interest and collaboration in ongoing projects

American Library Association
Collaborative Workspace

- Not a machine shop
- Allows students to work and socialize while they design, build, assemble, test, and create
- Near the fabrication and meeting spaces

The Foundry at Duke University

UC Berkeley CITRIS Invention Lab
Collaborative Workspace

Yale Center for Engineering Innovation and Design

Northwestern University Segal Design Institute
Fabrication Space

- Can be divided into purpose-driven spaces for each technology
- Can be more of a workshop environment

TechShop Austin  
MIT Pappalardo Design Laboratory
Design Space / Meeting Rooms

University of North Carolina Chapel Hill Makerspace
Design Space / Meeting Rooms

The Foundry at Duke University
Instruction Space

- Setup like a open format classroom
- Preferably close to the workspace so instruction can happen in both a fontal lecture mode and within the workspace

Yale Center for Engineering Innovation and Design
Layout Example – Yale CEID

Second Floor

Ground Floor

Ground Floor

Second Floor

Meeting Rooms

Wet Lab

Machine Shop

Wood Shop

Studio

Lecture Hall
Layout Example – NJIT Makerspace

Ground Floor (Under Construction)  Second Floor (Under Construction)
Staffing and Operation

• Staffing Models
• Types of Staff
• Operation Hours and Access
Staffing Models

• Three different models (and several hybrids)
  – Employee Operated spaces:
    • Spaces typically have a director, full time machinists, design mentors, and student staffing
  – Student Operated spaces:
    • Spaces typically have a part time director and make use of students to staff and operate the space
  – Faculty Operated spaces:
    • Following the models that use faculty to run academic labs/ fabrication centers

Student Operated
Boston University
Harvard University
Columbia University

Faculty Operated
Case Western University

Employee Operated
Arizona State
Cal. San Diego
Colorado State
Lehigh
Northwestern
## Types of Personnel

In many spaces these roles are shared and can be paid or unpaid

<table>
<thead>
<tr>
<th>Position</th>
<th>Responsibilities</th>
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</thead>
<tbody>
<tr>
<td>Director</td>
<td>Management, Scheduling, Outreach, Administration</td>
</tr>
<tr>
<td>Design Mentor</td>
<td>Teaching, Consultation, Course Work Development, Training, Supervision</td>
</tr>
<tr>
<td>Faculty</td>
<td>Teaching, Consultation, Course Work Development, Training, Supervision</td>
</tr>
<tr>
<td>Machinist</td>
<td>Training, Research Machining, Maintenance, Supervision</td>
</tr>
<tr>
<td>Graduate Student Worker</td>
<td>Training, Maintenance, Supervision</td>
</tr>
<tr>
<td>Student Worker</td>
<td>Training, Maintenance</td>
</tr>
</tbody>
</table>
Training

- Training can be performed by staff members or experienced students or student workers
Training

• Provide a clear path to mastery of skills and machines
• Incentivize students to promote mastery, safety, and skills
Employee Staffed Spaces

• Director oversees operations and manages the staff members
• Staff members typically consist of:
  – Machinists
    • Professionals trained in fabrication and operation of machinery, typically have an educational background a degree in an engineering discipline. Typically responsible for training students and equipment maintenance.
  – Design Mentors
    • Experienced engineers with ample design and fabrication experience. Typically have advanced degrees in engineering (in some cases a Ph.D.). Teach classes and train students.
  – Student Workers
    • Graduate or undergraduate students who have demonstrated responsibility and skill in making. In some cases, responsible for a portion of student training and equipment maintenance.
Employee Staffed Spaces

• Benefits
  – Ability to give users access to more advanced and capable machinery
  – Users have guaranteed access to professionals with design, fabrication, and prototyping experience
  – Ability to rigorously control safety and training

• Drawbacks
  – Cost (staffing is expensive) although though the use of student workers cost can be controlled
  – Sometimes difficult to maintain wide operational hours
  – Can be difficult to build a sense of community
Student Staffed Spaces

• Part time director or faculty member oversees operations and manages the staff members
• Staff members typically consist of:
  – Contributing faculty members
    • Faculty voluntarily contribute to the operation and use of the space
  – Students
    • Students voluntarily contribute to use, maintenance, and training

• Spaces are managed much like a student club
**Student Staffed Spaces**

- **Benefits**
  - Lower cost
  - Quick startup. Often easy to advocate for a small amount of resources to open a space, show usage, and grow
  - Good model for spaces (or portions of a space) with less dangerous equipment
  - Highly dependent on the interest and dedication of students

- **Drawbacks**
  - Difficult to maintain safety on more dangerous equipment so the capabilities are often limited in these spaces
  - Can be difficult to plan and keep the space continuously staffed
  - Highly dependent on the interest and dedication of students
Faculty Staffed Makerspaces

• Not a common model

• Follows the practice of some schools to have a faculty member in charge of large laboratories/ fabrication centers

• Advantages
  – Fits into existing models of managing laboratories
  – Provides direct link to the faculty and to curriculum development groups
  – Continuity and Stability

• Disadvantages
  – Not a typical set of activities, responsibilities and skills for a faculty member
SAFETY FIRST
Safety and Training

Safety is the most important aspect of any Makerspace facility!

Operation of the facility should focus on:
  Early and Easy Access to Training
  Community Support
  Information Sharing
  Creating a Culture of Safety and Learning
Training

• Must be accessible, reasonable, and attainable
Facility and Safety Orientation

• Introduce students to the facility and staff
• Discuss the mechanics and culture of the space
• Discuss policies in the space and encourage safety
• Educate students on basic safety procedures and equipment
• Discuss what to do if something happens
  – First aid station locations
  – Who to call
• Discuss training policies and how to get trained
Safety and Training: Equipment Use

• All users of a machine must have some training on the machine
  – The level of training and supervision needed depends on the complexity and danger level for the machine

• Continuing Safety at the Machine
  – Refresher sheets
  – Operation checklists
  – Posted guidelines
  – Labeled pictures and machine parts
  – Contact information for machine help
  – Links to refresher videos
  – Access Control Systems
Safety and Training on Equipment

- Can have different policies based on the machine complexity or danger level

<table>
<thead>
<tr>
<th>Safety Level</th>
<th>Description</th>
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<tbody>
<tr>
<td>Level 1</td>
<td>Low Power Hand and Small Benchtop Tools</td>
</tr>
<tr>
<td>Level 2</td>
<td>Medium Power Tools</td>
</tr>
<tr>
<td>Level 3</td>
<td>Powerful Portable Tools and Benchtop Tools</td>
</tr>
<tr>
<td>Level 4</td>
<td>Light Industrial Tools</td>
</tr>
<tr>
<td>Level 5</td>
<td>Large Industrial Tools</td>
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</table>
Access

• Typical Operation Models
  – 24 Hour Access
    • Many makerspaces are open 24/7
      – Restrict access to more dangerous equipment in the evening and overnight hours
    • Employees are present during business hours and often extend into the late evening
Equipment Use: Access Control

- Some Common Access Models for Equipment
  - Unrestricted Access
  - Partially Restricted Access, Buddy Required
  - Restricted Access, Supervision Required
  - Restricted Access, One-on-One Supervision Required
  - Only Staff Use

- Many ways to implement access models
  - Place machines in controlled rooms
  - Machine lock out with keys
  - Power lock out
  - Automated access control
Equipment Use: Automated Access Control
Equipment Use: Tool Control

- An organized and professional space aids in safety, usability, and responsibility
- Control and tracking of tools can become a big issue
- In high capacity spaces, it can hinder functionality and raise costs
- Spaces should make sure that:
  - Users are responsible with their use and storage of tools
  - Tools are returned to their proper locations
  - Work areas are kept clean and free of excess tools
  - Tools are respected and users learn the correct tools for the job
Tool Use and Organization

• Tool Control Systems
  – Options range from very simple to fully automated

• Visual Systems:

  Snap-On Visual Tool Control

  High Contrast Foam Drawer Insert
Tool Use and Organization

• Automated Tool Control
• For high volume spaces
• Can provide absolute accountability and can dramatically lessen staffing needs

Snap-On Level 5 ATC Chest
Snap-On Level 5 ATC Locker
## Equipment

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>State-of-the-Art</td>
<td>5-Axis and Higher CNC Metal Work, 5-Axis Water Jet, EDM, Metal 3D Printing, Vision Metrology, CNC Metrology</td>
</tr>
</tbody>
</table>
Fundamental Equipment

- Hand Tools
- FDM 3D Printers
- Small Laser Cutters
- Basic Wood Tools
- Soldering, Test, & Measurement
- Hand Metrology
Intermediate Equipment

Manual Metal Work

Welding

Advanced Wood Tools

3D Scanning

SLA and UV 3D Printing

Manual SMD Electronics Assembly
Advanced Equipment

CNC Metal Work

Water Jet

CNC Wood Work

Automatic Electronics Assembly

Multi-Material 3D Printing

Fiber Laser Marking
State-of-the-Art Equipment

- 5-Axis and Higher CNC Metal Work
- 5-Axis Water Jet
- Wire and Sinker EDM
- Vision Metrology
- Metal 3D Printing
- CNC Metrology
Project Storage

- Storage is often overlooked
- Students need space to store projects (daily & by semester)
- Many automated and manual locker systems
Cost of Consumables

• Should you charge for consumables?
  – How to handle items like drill bits, end mills, nuts and bolts, etc…
  – Manage manually or automatically, depending on volume
  – Many spaces consider this a cost of operation
• There are industrial vending solutions from companies like Grainger, MSC, Supply Pro
Automated Consumable Control

- Access cards control who can access what parts
- Students can have free access to common and low-cost items
- Require an administrator to access costly or controlled items
- Some companies will automatically restock inventory at no cost
- Some companies will provide the hardware at no cost!
Cost of Operation

- Need to support
  - Purchase of equipment (initial, upgrades, and expansion)
  - Operational costs

- Internal and External Sources of Funding
  - Internal (line item budgets, charge for use)
  - External (fundraising, grants, external users)

- Many examples of spaces that support both internal and external users both free and paid
Cost of Operation

- Spaces can serve:
  - Students (Course work, self-initiated projects, entrepreneurial projects, undergraduate research)
  - Research (Test setups, fixtures, systems, etc…)
  - External schools (High schools, middle schools, summer camps)
  - External users
  - Collaborative research with industry
Usage Fees

• Many spaces are completely free for students use
  – Reasonable limits are typically placed on the size, time, and usage of more costly equipment

• Some spaces charge for usage of equipment such as:
  – 3D Printers (Per gram of printed part or minute machine time)
  – Laser Cutters (Per minute of cutting time)
  – CNC (Per minute of cutting time)

• There are many manual and automated ways to track and manage these transactions
Thank You

Questions?