My name is Tom Burtonwood and I am an Assistant Professor at the School of the Art Institute of Chicago teaching mostly in the Department of Contemporary Practices – which is our first year or foundations program and a class each year in our Sculpture Department. My focus in the classroom revolves around 3D printing, digital fabrication, new media and three dimensional work in general.
Talking Points

“Beyond the inflection point - lessons learned from 3D printing at the School of the Art Institute of Chicago” This talk outlines how the introduction of desktop 3D printing at SAIC has changed the culture making and meaning on campus. When I began researching this presentation I started out by interviewing many of my colleagues involved with 3D printing and digital fabrication at the school, faculty and staff alike. My hypothesis was that the emergence of desktop / DIY 3D printing had caused a paradigm shift in the way we taught sculpture and design at SAIC. But what I found out during these conversations was an even richer narrative, a deeper history. SAIC is an interdisciplinary art school and digital fabrication with 3D printing in particular is well suited to serving this type of learning / making community. The recipe for our success introducing 3D printing to the SAIC community is two scoops desktop printing, a cup of high end production machines and a hearty portion of support staff who ensure everything happens on time and on budget.

Over the course of the next twenty minutes or so I plan to briefly introduce
1. a history of new media and technology at SAIC,
2. the origins of our interdisciplinary approach
3. the introduction of desktop 3D printing to campus
4. some of the outcomes faculty and students have created
Founding of SAIC

Founded as the Chicago Academy of Design in 1866, the School of the Art Institute of Chicago (SAIC) provides a challenging education in the studio arts and exhibition opportunities for its students. The school incorporated as the Chicago Academy of Fine Art in 1879, and changed its name to the Art Institute of Chicago in 1882. The museum and school moved into a building designed and built for the World’s Columbian Exposition in 1893.

Throughout the history of SAIC, alumni have played central roles in important art movements. It was SAIC that provided the impetus for two significant schools of American painting—the Regionalists of the 1930s, and the Imagists of the 1960s. Some of the most notable names in the arts received their early training at SAIC, including Georgia O’Keeffe, Claes Oldenburg, H.C. Westermann, Thomas Hart Benton, Grant Wood, Ivan Albright, Ed Paschke, Roger Brown, Halston, LeRoy Neiman, Elizabeth Murray, Cynthia Rowley, David Sedaris, Rirkrit Tiravanija, and Sarah Vowell.
Techniques like oil painting and bronze casting are often considered to be traditional and very analogue. But they are also workflows that demand a significant degree of skill and learning. We often talk about STEAM and STEM as if art and design was somehow an add on to these other disciplines forgetting somehow all the chemistry, physics and math that goes into successfully pouring bronze, mixing pigments, firing earthenware and making molds.
Art Schools are the Original Makerspaces

As my colleague Brad Johns, Executive Director of Fabrication Instructional Resources likes to say – “Art school is the original maker space.” – artists, designers, artisans, craftspeople alike have been developing systems and spaces for pedagogy and production for a long time and an interdisciplinary art school like SAIC is the logical and radical expression of this idea.
Generative Systems

While there is a strong emphasis on traditional modes of making at the School of the Art Institute of Chicago there is also an innovative, often faculty led, program of integrating new and advanced technologies into the campus community. In the late 1970s Sonia Landy Sheridan a faculty member teaching printmaking started using a refurbished Thermo Fax machine that she had purchased from 3M. Sheridan saw the potential for the mediated production of images and mass distribution or multiplicity of them. From there a course called Generative Systems was born bringing together students, scientists, technologists, industry, artists and the academia.
Generative Systems

“Art will continue to remain on the entertainment pages, peripheral to society, unless artists take their rightful place along with scientists in molding our new information architecture and language content.” — Sonia Landy Sheridan, “Generative Systems Versus Copy Art: A Clarification of Terms and Ideas,” Leonardo, spring 1983

The School of the Art Institute of Chicago’s (SAIC) Department of Art and Technology Studies was the first of its kind in the country. It was created by merging the areas and interests of two visionary artists who began working at SAIC in the 1960s, Professor Emerita Sonia Landy Sheridan and Professor Emeritus Steven Waldeck.
Art and Technology

Sheridan and Waldeck explored emerging technologies and were dedicated to disrupting traditional modes of art making. The story of this radically innovative department begins with an industry partnership between Sheridan and 3M Corporation that drew the attention of the school administration. At the same time, SAIC hired Waldeck, who had been working with technology and kinetics in his art practice since he was an undergraduate student. Sheridan’s curriculum dealt with the underlying systems, while Waldeck’s technical abilities tended toward the physical construction of technological forms.

Today, Art and Technology Studies students can study: experimental visualization and fabrication; performative objects and responsive environments; bio art; embodied networks; creative coding; open source; thinking, creating, and designing with light; virtual and augmented reality; hypertext; and the history and theory of art and technology studies.
Interdisciplinary origins

The School of the Art Institute of Chicago is an interdisciplinary institution. The genesis of which originated in 1983 with the establishment of a media center to check out equipment related to the production of images and time base media. At the time the administration worked on a philosophy that remains to this day that the limited resources we have should only be invested in equipment that is open to all. In this fashion painting students could check out video equipment and film makers can use sewing machines.
Department of Contemporary Practices

My Department, Contemporary Practices is an interdisciplinary department. We have an incoming class of around 800 freshpeople each year. Our incoming students are required to take two courses in the department of Contemporary Practices, “Core,” which spans both the fall and spring semesters and “Research Studios 1 and 2” which are in the fall and spring semesters respectively. Core is intended to teach workflows and methods of making. Research asks why something is being made and what the conceptual framework is, that it belongs to. Our Freshpeople also get to choose an elective course each semester in other Departments that fit with their current interests and pathways – so for example a class in art and technology, plus an intro to art history course. As the students matriculate though the institution they do so without having to pick a major or an area of focus. They are free to take classes as they see fit.
Digitarium

Others departments have less pre-reqs and so it’s not uncommon to be teaching a 3D printing module to students with no experience of 3D modeling, scanning or digital fabrication from across the student body. That said since 2014 many of our incoming students do receive 3D printing as part of their Core or Research Studio experiences and as those students move through the school they take those skills, expectations and abilities with them. Often they end up working in one of our fabrication facilities and they in turn share their experiences and techniques with the campus community as a whole.
Sharp Instructional Shop

As an interdisciplinary institution it is vital that we have a porous system to support our porous curriculum. By that I mean that if the curriculum is open to anyone the systems that support it must be equally as accessible. Our open approach to designing a curriculum is scaffolded and supported by IRFM and CRIT who staff and manage our campus fabrication and information technology resources. SAIC endeavors to support an open shop policy, meaning students, faculty and staff can access any of the on campus resources, be authorized for specific tools as needed and have things made at any of our service bureaus. In practice the campus environment doesn’t always permit a completely open approach but pathways do exist for anyone in the campus community to access them. Historically this system has grown out of necessity.
First desktop machines

When we started desktop 3D printing in Contemporary Practices we began with Makerbot Replicator 2 machines which worked really well for the first 18 months or so, but as they shifted over to the 5th generation machines we made a decision to switch, first to Dremels as they fit our existing workflow and now to Ultimakers as the quality and reliability of the machines won out over the affordability and limited slicing software. This is a good example of where we pilot a machine in a high volume department like Contemporary Practices and then use the lessons learned to help inform purchasing and deployment across the institution as a whole.
Everything happens on stage

From a financial point of view SAIC simply cannot afford to have equipment that is only available to one department. Furthermore we cannot promote an ethos of interdisciplinary enquiry if our equipment and tools for making are in roped off in silos around the campus. At SAIC we do not have a research center where faculty or staff get to test out new systems before deploying them. We don’t have the real estate to support this type of activity. As a result everything happens on stage. Technology has to be tested, refined, deployed in full view. It also has to work - we focus a lot on how a product is supported by the manufacturer, and that can be a big deciding factor when it comes to selecting equipment and purchasing it. Typically we will pilot a system, test it with a core group of faculty / staff / students before deploying it.
We also have to avoid false expectations. Students and faculty alike have to understand what a tool can and cannot do. With 3D printing that’s often difficult as many first time users come with the idea that it is fast, cheap and they can make anything. As we all know you can usually have two of those three. In short the rhetoric and reality rarely match up first time around. So we need to have support staff in place to guide students and faculty alike through the 3D printing learning experience. One of the vital parts of the puzzle though is not so much the support that happens in class but rather outside of it.
Support, support, support

Talking to fellow educators at other institutions one of the thing I realized about SAIC is that we have really good support outside of class time – students can individually check out a 3D printer, sometimes for twenty four hours at a time in order to print ambitious, innovative projects that would be impossible to facilitate during a normal 6 hours class with 15 – 30 students to work with. This accessibility is directly tied to the same openness students enjoy with regard to other on campus equipment from table saws to laser cutters, kilns, looms and sewing machines alike. So a big takeaway for me as regards 3D printing at SAIC is support, support, support.
Interdisciplinary ecosystem

At the heart of our technology on campus has been a simple premise that of serving and promoting an interdisciplinary community. First with the Media Center in 1983 and later with the Service Bureau in 1999 a combination of cost saving measures and open access produced an ecosystem whereby advanced technologies are available to a wide range of creative practitioners. Our first service bureau was made possible by cost saving measures that centralized our campus wide administrative printing needs into one facility.
SAIC Service Bureau

These savings were used to buy several large format mural printers and establish the first SAIC Service Bureau, The School of the Art Institute of Chicago’s on-campus professional digital-output center, specializing in laser printing and archival, wide-format inkjet printing. The Service Bureau provides printing and finishing services to students, faculty, and staff as well as inform and instruct on proper file setup, color management, resolution, file management, print longevity, and paper types.
Advanced Output Center

In 2007 3D printing came to SAIC via our Advanced Output Center in the form of a Stratasys Dimension FDM machine. Today the AOC boasts an Objet Printer and a couple of laser cutters. They have experimented with self service desktop machines and report that students often use those first to test ideas out before creating production pieces on the higher end machines. Interestingly though the Dimension and Objet alike are being eclipsed in popularity for high resolution output by Formlabs Form 2 SLA machines.
The first faculty to start teaching 3D printing as a sculptural medium was Film, Video, New Media, Animation faculty Claudia Hart who started working with the Dimension once it arrived on campus. Hart demonstrated the hardware and software in class, testing it with the students and immediately seeking the breaking points. Hart talks about how the early prints from industrial designers that she saw coming off the machine were humorless and lacked character. She encouraged her students to use a workflow developed first using Z brush to create surfaces that simulated organic natural forms and then using off the shelf dental scanning software to create manifold objects. Hart found that even then her 3D models were still defeating the Dimensions slicing software and so she found a way to shrink wrap the models using an online service called CADSPAN to create a fresh mesh that was both watertight and manifold.
Replicator 101

The problem with a machine like the Dimension however is that even at cost it is relatively expensive to print on at $5 a cubic inch and it presents a bottle neck where many project are queued up to print and it proves difficult for students and faculty alike to get projects printed on time.

Desktop 3D printing arrived at SAIC in the fall of 2012 in an adhoc fashion when I brought my first machine, a Makerbot Replicator 1, into class during the fall semester and demonstrated it to my students and colleagues. Injecting 3D printing into the Freshpeople experience was an important way to shape expectations moving forward, and to demonstrate that if first year students could get good results out of these machines that undergraduates and graduates alike throughout the school would also benefit from their use.
I started teaching 3D printing in the spring of 2012 with a Research Studio in CP called “Adventures on Planet Xerox” it was an introduction predominantly to 3D scanning which has always been my main focus in digital fabrication and for me something that I consider to be an extension of photography. I told the students on day one that I considered the purpose of a Research studio to be a place where we as a class conducted research and learned about new workflows, concepts and ideas. I explained that this was a subject I was deeply researching but did not know all of the answers to. The students to their credit took this and ran with it and produced some really good outcomes pushing themselves to the limits of their ability with software and hardware alike.
Research Studio 2: AOPX

There was something about that moment in 2012 it really felt like anything was possible. Sophie Kahn came to talk to my students about her work she was in the middle of her MFA at SAIC at the time. Bilal Ghalib also came to talk to the class in the middle of the Pocket Factory tour around the USA and brought an UP! Printer and showed it off to the students. Despite the difficulties with output the class was very rewarding and we were able to use 123D Catch and Kinect scanning apps like CocoaKinect and Meshlab to develop successful workflows.
AIADO Introductory Course: Brian Anderson

In the late summer session of 2013 AIADO faculty member Brian Anderson introduced a RepRap driven introductory class for incoming grad students at SAIC. Partnering with Printrbot Andersons class had 15 early versions of the Simple one distributed to each student. This was an attempt to solve the bottleneck problem experienced with the Dimension and gave the students a hands on experience with building and maintaining their own 3D printer – an experience that the service bureau model in the AOC explicitly did not allow for. The outcomes from Andersons class were unexpected, students found the Simple machines difficult to work with. These early versions did not even have homing switches and as such were very difficult to work with. The takeway at the time was that RepRap machines were too difficult as a whole for our institution to support due to the maintenance needed to run them effectively.
Core Studio: Amalgamate “Tool Project”

In the fall of 2013 our department had acquired four makerbots and my colleague Burt Isentstein and I jumped into figuring out how to teach them. It’s going on five years now that Isenstein and I have been teaching 3D printing together. Our first projects was something we just called the “Almagamate – Tool Project” it was an assignment that introduced 3D printing and the woodshop together. Students were authorized on the table saw and the 3D printer in the same assignment. We were keen to make it clear that they were both powerful tools in their own right but that together the hybridization of output could create some very startling results.
Isenstein notes that adding 3D printers to CP’s tool set was a game changer as it was the first direct access to an actual digital tool where faculty and students could design and output a digitally generated object. The laser cutters had been around for a number of years but since they were in a different department and weren’t as hands on he didn’t have the confidence to use the tool well enough to use it as a teaching tool. He continues that the physical presence of the printers and the ability to work from model to printer output along with access to Tinkercad (at first) and transitioning to Rhino provided him with the path to incorporate additional digital tools (plotter cutter, CNC mill, laser cutter) into the classroom and his own studio practice.
For Isenstein the more the 3D printers are integrated into the curriculum as one of a variety of
digital fabrication tools the better such as this slide which shows a project that utilizes the 3D
printer and plotter cutter to produce a lifelike facsimile of a retail product. Isenstein notes how 3D
printers are really good for certain tasks, but that their appropriateness depends on what students
are trying to make. Having the printers in the classroom to work with directly is invaluable.
Watching a printer operate is a good way to begin to understand and develop a vocabulary about
3D form. Being able to use the printers, load filament, level, etc. is good as it demystifies the
process and allows students to develop an understanding of how the tool actually works.
The “Digitarium”

Our initial foray into 3D printing saw the machines operating on carts that could be wheeled to the classroom and after class accessible intermittently in a storage space in the department. The following year we were able to create a purpose built maker space that we named the Digitarium. The argument we made to the administration is that these machines represented the “thermo fax” of this generation. Did we want to be the school that saw the promise of the laser printer but missed the boat on 3D printing? The Digitarium quickly became a must see stop on any admissions tour and proved to be an excellent gateway for incoming students to the interdisciplinary possibilities SAIC can offer.
Core Studio: Making Multiples

More recently Isenstein and I have been teaching 3D printing in conjunction with mold making and casting as a multiples project. We introduce 3D modeling in Rhino to produce patterns for mold making, 3D printing those patterns that in turn create plaster molds and wax casts which in turn become multiples. I think the similarities between the 3D printing and mold making are really useful and teaching both disciplines together makes a lot of sense, Undercuts and overhangs are so closely related, as is support material and thinking about parting lines on the mold. In this slide Core student David Karisny combines physical computing, 3D printing and performance to create a work of art drawing upon his experiences to talk about endurance, recovery and data visualization.
Adventures on Planet Xerox: Suspension of Disbelief

I taught Planet Xerox a further two times. I expanded the syllabus this time to include access to the newly established 3D printers in the Digitarium. My favorite project from both courses was a project where I paired the students up and had them produce a short film / animation using 3D printing to create the props or the animation assets. I liked this project because the 3d printed elements were not the final piece per se but represented an integral part of the project nonetheless. I also felt that this project tied in really well with actual industry uses of 3D printing. This slide shows a project by Jenny Chen and JP Brown where they made a short film about origins of humanity.
Digital Foundry: machined wax / investment casting

Collaboration between faculty, staff, students and the administration has been key to making this system of experimentation with technology work. I have been closely involved with an effort over the last two years to introduce digital pathways into the Foundry to try to open up metal casting in the same way we have opened our wood and metal working shops. In the first iteration of the course we focused on using the desktop CNC mill, the Othermill to machine wax for centrifugal investment casting in bronze. We used RhinoCam to export toolpaths for the Othermill and Otherplan to run the nc file on the machine. Despite the bottlenecks created with only three machines we were able to get some good pieces cast in bronze. In the second iteration of the course we attempted to print in wax using a wax filament. We had limited success with this, a number of the staff and student workers had some good outcomes but we had a hard time replicating them in the classroom.
**Digital Foundry: Lost PLA / ceramic shell casting**

Cody Norman who started at SAIC as a student and now works in the Sharp Instructional Shop also has been experimenting with Lost PLA ceramic shell casting. This slide shows a voronoi vase he printed on the Printrbot Simple made a ceramic shell mold around it, before burning out the PLA and casting it.
Graduate student Elizabeth Nelson was also successful printing wax pieces which we cast in aluminum using the centrifuge in the Materials Lab. Nelson talks about her process as follows - As always in good research, she would attempt to change one variable at a time, leaving the other elements as controls. For example, she would observe the effect of increasing the print speed, while keeping the other settings the same. She notes importance of repeating an experiment and/or peer review!

Nelson also talks about another difficulty faced in 3D printing is the fluctuation of settings needed from model to model, based on things such as size, shape, or surface area of the base. Keep in mind, there is not one system or setup that will work for every single print, every single time. Because of this, it is even more important to understand why what is happening to a print is actually happening.

*Gyroid design by Seth Moczydlowski*
Digital Foundry: Lost plastic / ceramic shell

Perhaps the center piece of our digital foundry project has been successful Lost Plastic Ceramic Shell bronze / aluminum casting in our foundry and iron casting off site. Our chimney stack has an inline afterburner that makes burning out ABS and PLA plastics possible. This slides show some process images. Assembling a 3D printed patterned with cup and sprues, dipping in the ceramic slurry, the finish ceramic shell piece, and burn out in the kiln.
Digital Foundry: Lost plastic / ceramic shell

In this slide we see the foundry workers heating the ceramic vessels, pouring the molds, the cooling shell vessel and the beginning of the divestment process. This process has not been without problems, especially with the gases during burnout from the plastic rupturing the ceramic exteriors. But overall it is a process students have been able to replicate. Most recently at our iron pour and it’s something I’m sure we’ll see more of.
As I mentioned earlier in preparation for this presentation I talked to as many of my colleagues as possible at SAIC in both faculty and staff positions about how they used 3D printing in their classroom and support roles. I’d like to present a few examples of their research or student outcomes and talk very briefly about their approaches. Art and Tech faculty member Brett Balogh teaches his students to hack the machines and the I/O lab certainly supports this hands on approach in a way that other labs might not. He encourages his students to develop algorithmic approaches to generating gcode and to approach 3D printing with much more of a hacker mindset.
Susy Giles / Julian Brooks

This piece by SAIC student Julian Brooks is in response to a prompt set by my colleague in CP Susy Giles who asked her students a brief to make a work that responds to their experience of a specific site
Mie Kongo: Ceramics and Architecture

Mie Kongo teaches in Ceramics and AIADO. Her Ceramics and Architecture class is a 3000 level course but because there is no prerequisite, the majority of her students are new to ceramics. (never touched clay before, never made molds before) She talks about how they are eager to make works but often times they have very little hand skills. Kongo talks about how 3d digital drawing software like Rhino is an excellent tool to visualize ideas quickly and rapid prototyping helps them to create quality final products.
Mark Stafford / Kennedy Jones

Mark Stafford is also working at the intersection of 3D printing and ceramics. He is using the Potterbot, a ceramic slip based extrusion machine. For Stafford the mechanical simplicity of the machine goes a long way toward demystifying 3D printing (which to many students seems like magic), yet the mesmerizing precision of computer controlled motion still powerfully engages their interest. Clay’s strict material constraints clearly demonstrate the limits of extrusion based printing, as well as the importance (and difficulty) of designing for particularly production methods. This in turn fosters a greater appreciation for the strengths (and weaknesses) of other 3D printing processes and materials, for other digital production methods (e.g. CNC), and also for traditional clay production methods. This slide shows work by Kennedy Jones who was one of my first 3D printing students in the 2012 iteration of Adventures on Planet Xerox
Daniel Baird / Austin Frisby

Daniel Baird teaches a course called Hybrid Objects in the Sculpture Department. In this assignment he asked his students to either:

1. create an object that could be used as a component in a system
or
2. utilize 3d printing in a novel way and bring it out of its ‘3d-printerness’

Austin Frisby decided to take it down a future archaeological route and sourced ‘wrong’ or damaged fragments from the printer bins at the Columbus AOC and then gilded them to present them as valuable relics.
Lessons learned

So what is the takeaway?

Our experience at SAIC suggests that a blended model with Service Bureau type options in conjunction with hands on opportunities to use the technology gives fledgling artists and designers alike a good range of skills and outcomes to work with. Higher end machines like the Dimension or the Objet give reliable results for those willing to wait and pay for them.

On the other hand desktop machines like our fleet of Ultimaker, Lulzbot, and Dremel machines give people affordable, hands on experiences at a fraction of the price of using higher end machines.

Desktop 3D printing encourages experimentation, promotes interdisciplinary workflows, gives more options in terms of materials and allows for a hands on experience with the technology.

In terms of generating the right critical mass staffing and facilities are key. Simply having the machines and expecting them to work without support is an exercise in futility.