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Exploring and Connecting 3D Printing to Teaching and Learning

Jason Spartz
Saint Mary's University of Minnesota, jspartz@smumn.edu

Lisa Truax
Saint Mary's University of Minnesota, ltruax@smumn.edu

Karen Sorvaag
Saint Mary's University of Minnesota, ksorvaag@smumn.edu

Brett Bodsgard
Saint Mary's University of Minnesota, bbodsgar@smumn.edu

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Jason Spartz, M.A.
Karen Sorvaag, Ed.D.
Lisa Truax, M.F.A
Brett Bodsgard, Ph.D.

Saint Mary's University
OF MINNESOTA

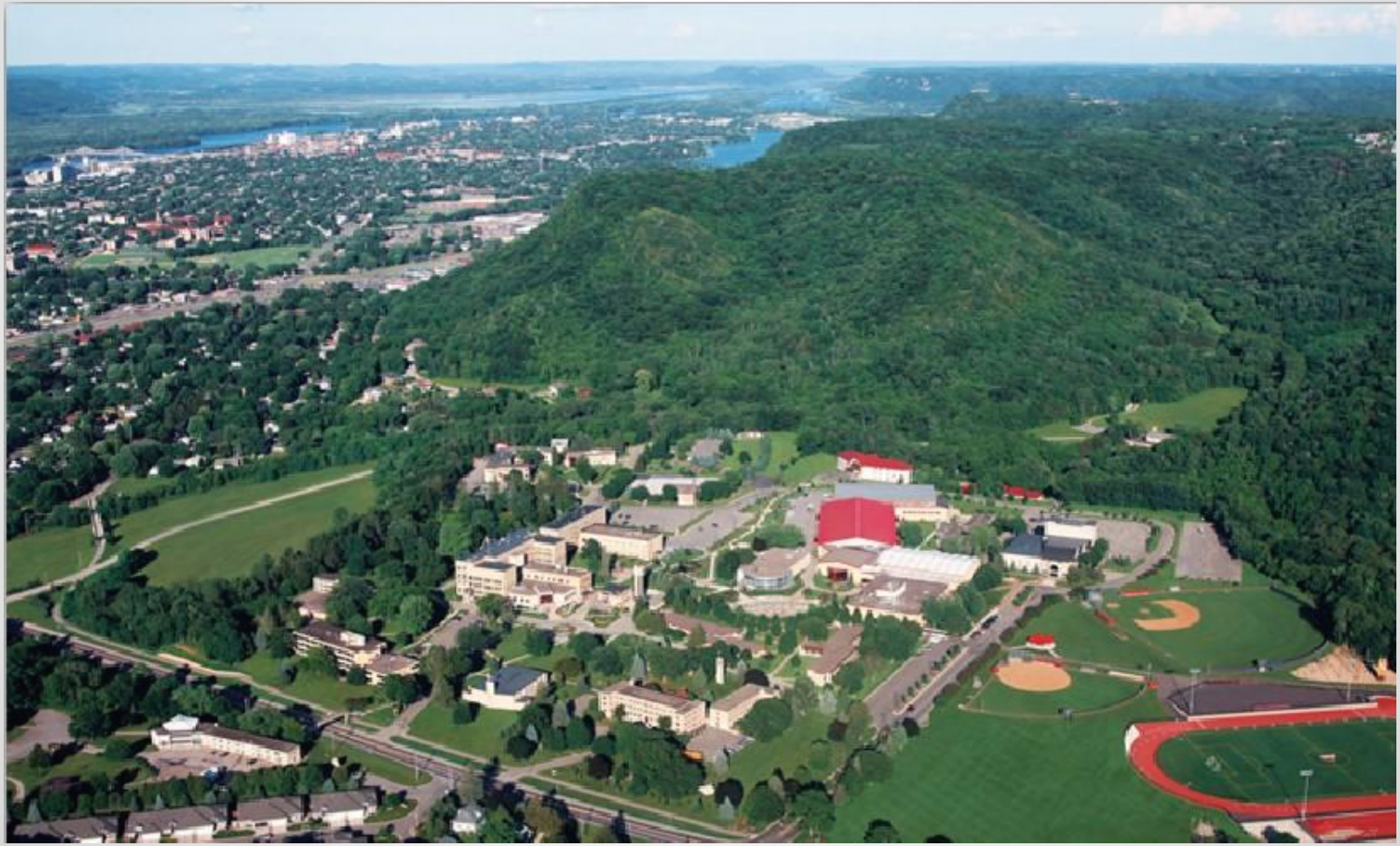
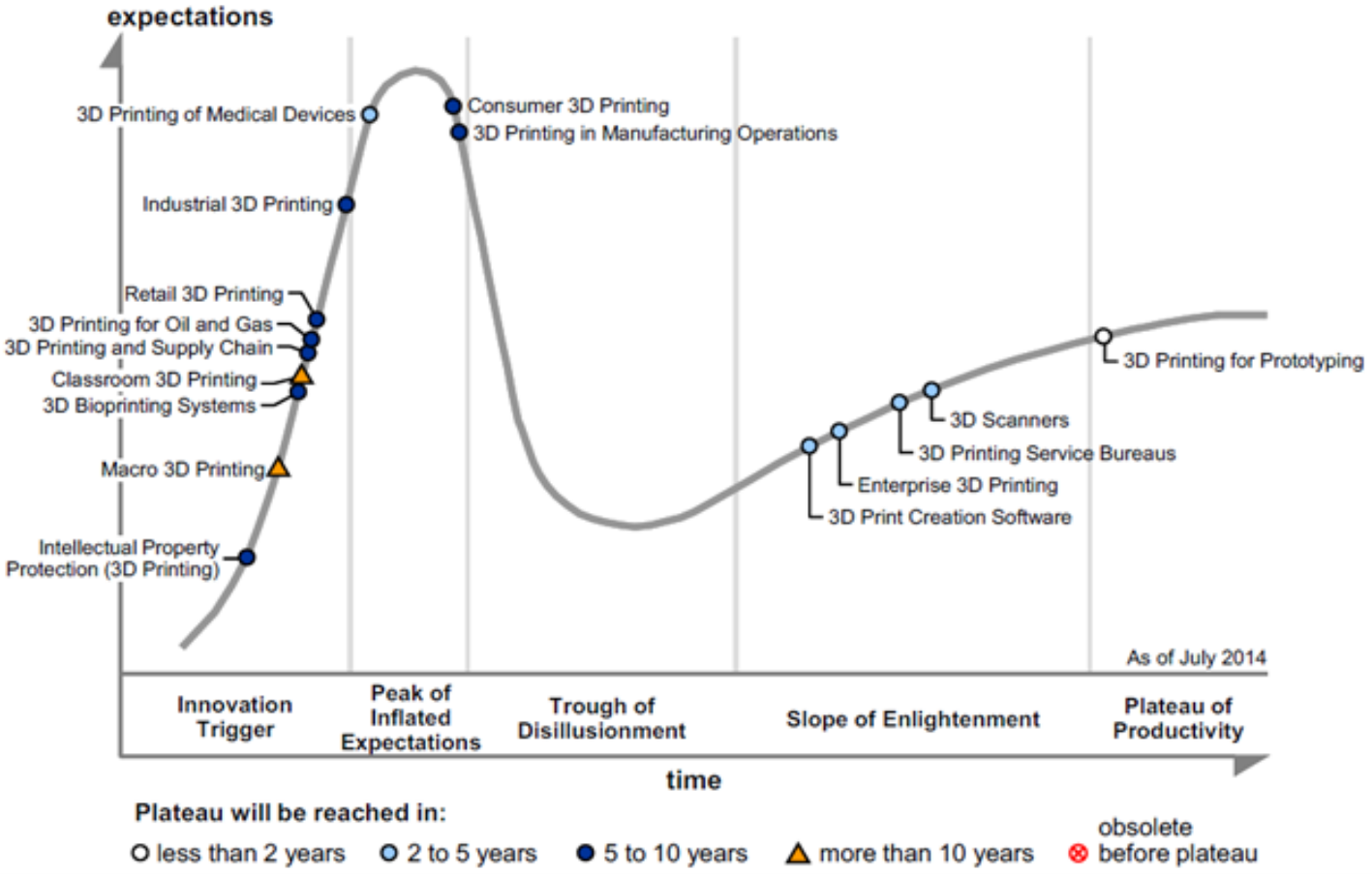


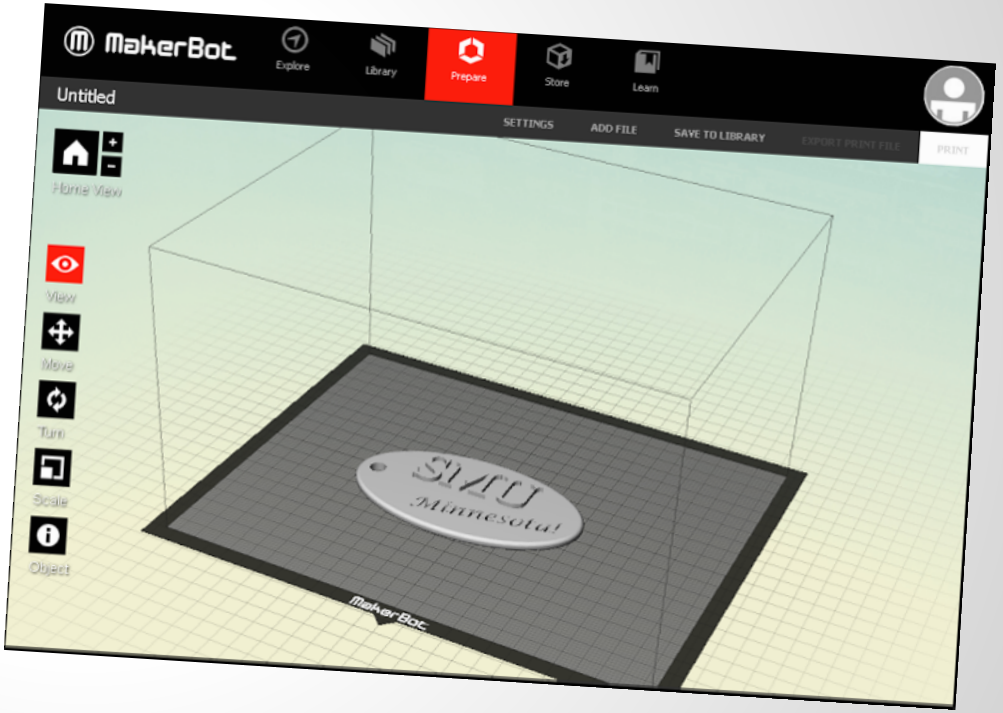
Figure 1. Hype Cycle for 3D Printing, 2014



Source: Gartner (July 2014) Retrieved from http://www.gartner.com/newsroom/id/2825417

Software

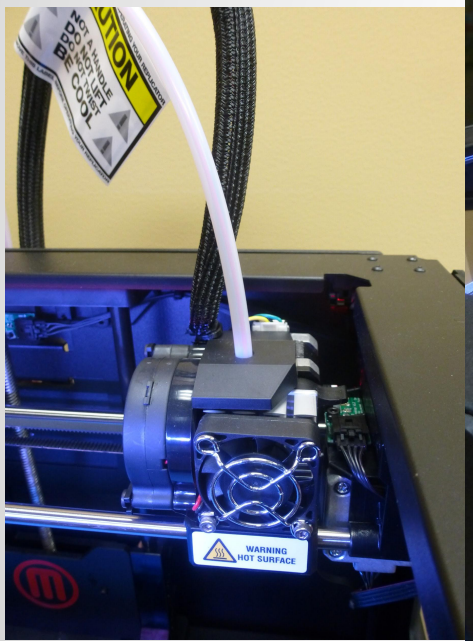
- The 3D print file marketplace
  - 3D Share
  - MakerBot - Thingiverse
- Autodesk 123D Design
  - Autodesk 123D Catch
- Meshmixer
- Google Sketch Up
- Rhinoceros (Rhino)
- Tinkercad

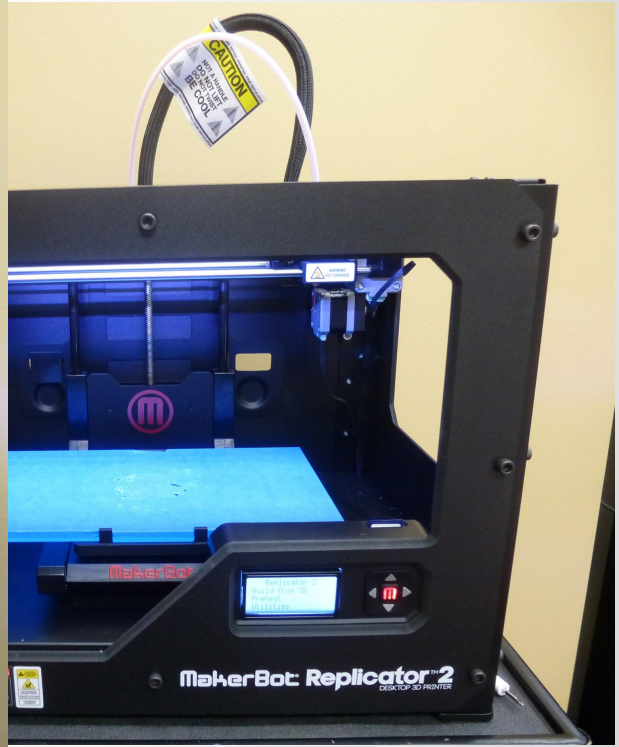


Printer Components

- Build plate (platform, table)
- Extruder
  - Heats up to around 230 degrees Celsius
  - Maintenance
- Filament is the primary ongoing cost.
  - PLA (polylactic acid)
  - ABS (acrylonitrile butadiene styrene)
  - Most printers are limited to one filament type (ours is PLA).
- Filament guide tube
- Spool holder

MakerBot Replicator 2



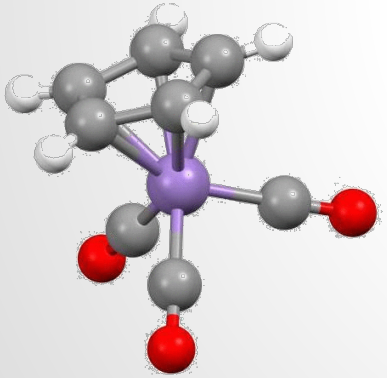


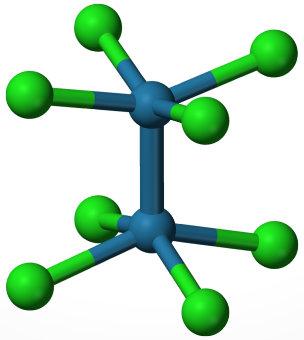
Approaches to 3D Printing Projects

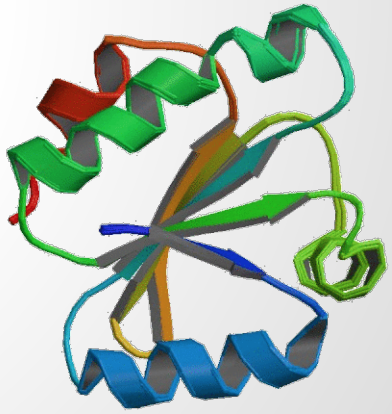
1. Not ready to go there with your students? Start on your own.
2. Shared experience by taking risks to learn technology (PBL).
3. Individual creativity and critical thinking experiences for student learning.

3D Printing in Chemistry/Biochemistry

3D printing as a tool to visualize and study structures that are not easily modeled







Molecule Representation

Chemical name and formula

Lewis structure

3D rendering in 2D

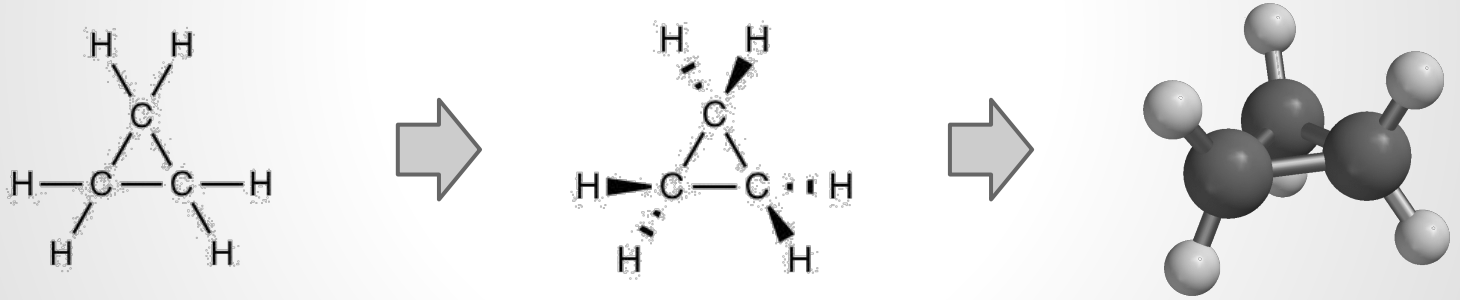
Computerized 3D rendering

Physical ball and stick model

3D printed model

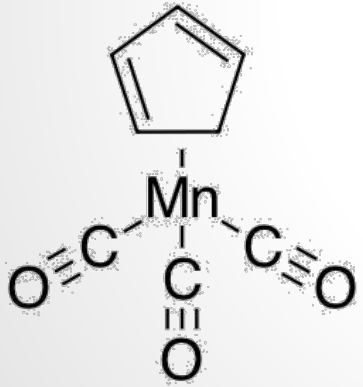
“Regular” Bonding

Cyclopropane, C_3H_6

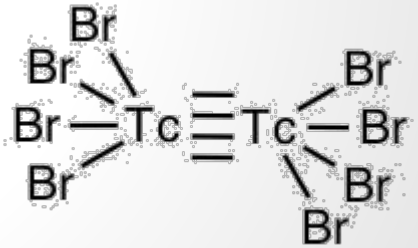


Unusual Bonding

$(Cp)(CO)_3Mn$

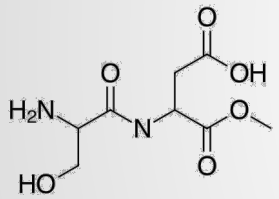


$[Tc_2Br_8]^{2-}$



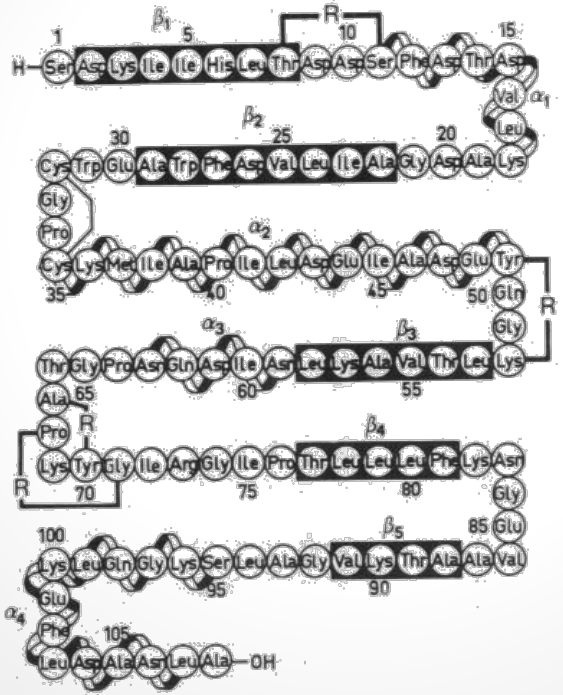
Protein Structure

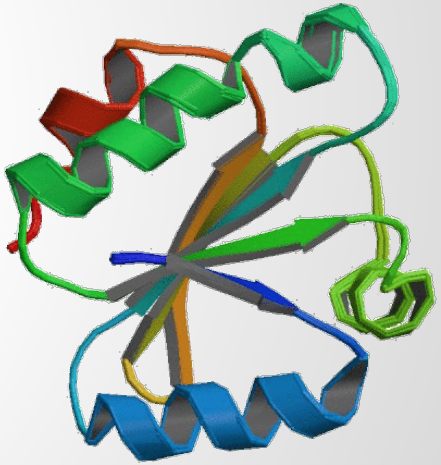
Thioredoxin



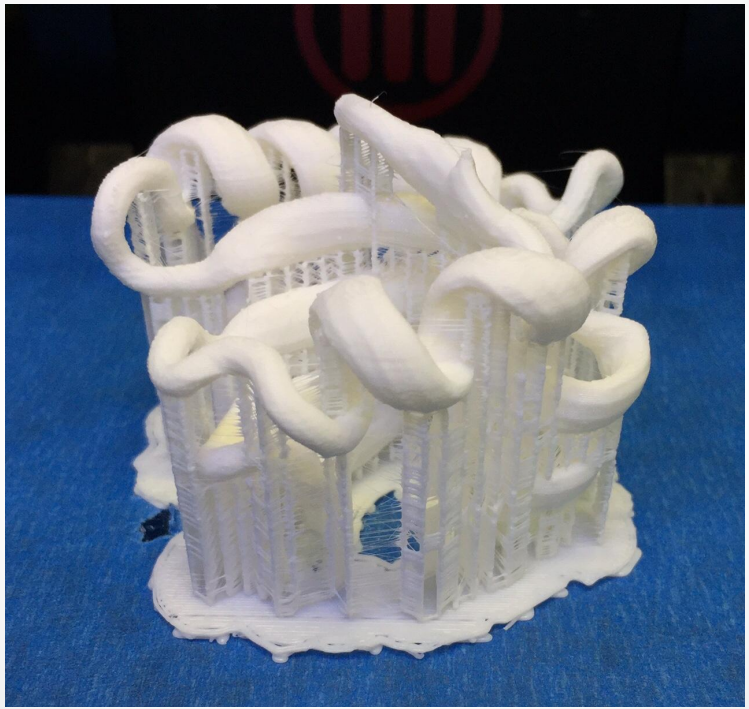
Serine-Aspartic Acid-

(~1500 atoms)





Printed Structure with Supports



Learning with 3D Printed Structures

Deeper questions/understanding:

1. How are bond types, lengths, and angles known?

2. Why and how does a molecule take the shape it does?

Beyond PLA 3D printing

Chemistry of PLA itself

3D printing with different materials

What else can be made (e.g. reaction vessel)?

Atom-by-atom printing (e.g. drug synthesis)

Chemistry/Science Resources

"3D Printing in the Chemistry Curriculum: Inspiring Millennial Students To Be Creative Innovators"
Luciano E. H. Violante, Daniel A. Nunez, Susan M. Ryan, and W. Tandy Grubbs

Addressing the Millennial Student in Undergraduate Chemistry. January 1, 2014, 125-146

DOI:10.1021/bk-2014-1180.ch009

Databases/resources (free) to obtain files:

Crystallography Open Database

Cambridge Structural Database

Protein Data Bank

Article supporting information

Programs (free) to manipulate/convert files:

VMD

Mercury

Chimera

Diamond Needle File Set

Getting Started with PBL and 3D Printing

- Find a friend
- Watch lots of Makerbot videos
- Play with Tinkercad and Autodesk123D Design app
- Create your first 3D printed object
- Celebrate! (hours later)
- Make a plan for your course or content

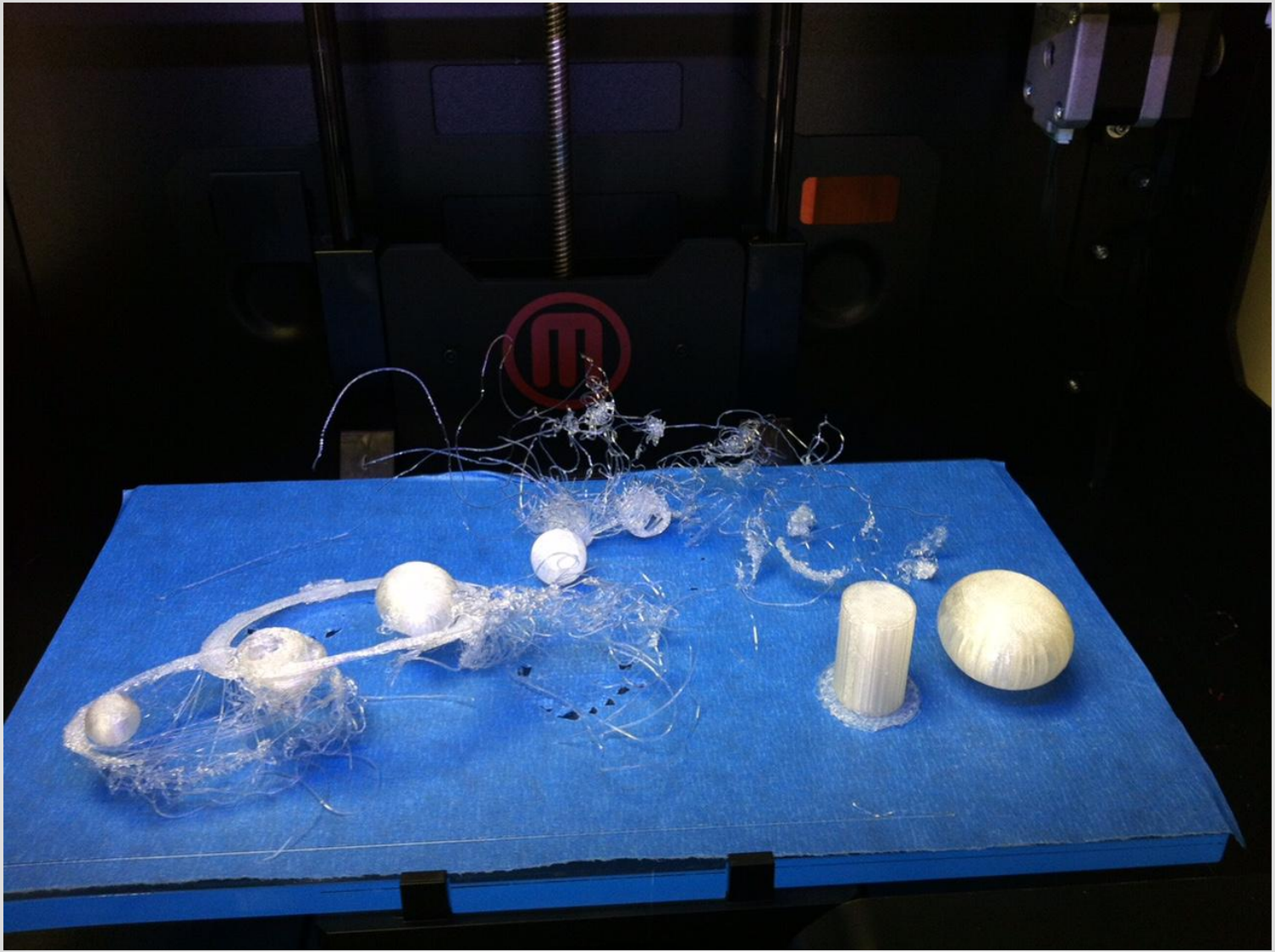
Problem-Based Learning and 3D Printing

The Problem in Brief:

- Learn how to use the 3D printer so you can teach your colleagues how to engage K-8 students in 3D printing projects.
- Connect the 3D printing project to K-8 science standards.
- Use your peers strengths to support your struggles.

Student Learning: Challenges and Successes

- Rely on your peers to share their insights about the software
- Connecting 3D printing to content was not difficult
- Sometimes you have to try many different ways
- Persistence pays off
- Having a team makes taking risks easier
- First ideas don’t always work out



Student Survey Results

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Collaborated well and shared responsibilities	7	3	2		
Considered varying perspectives	3	6	3		
Found enough resources to solve problem	4	3	5		
Took ownership of learning	7	5			
Confident in finding and using technology resources	8	2	2		

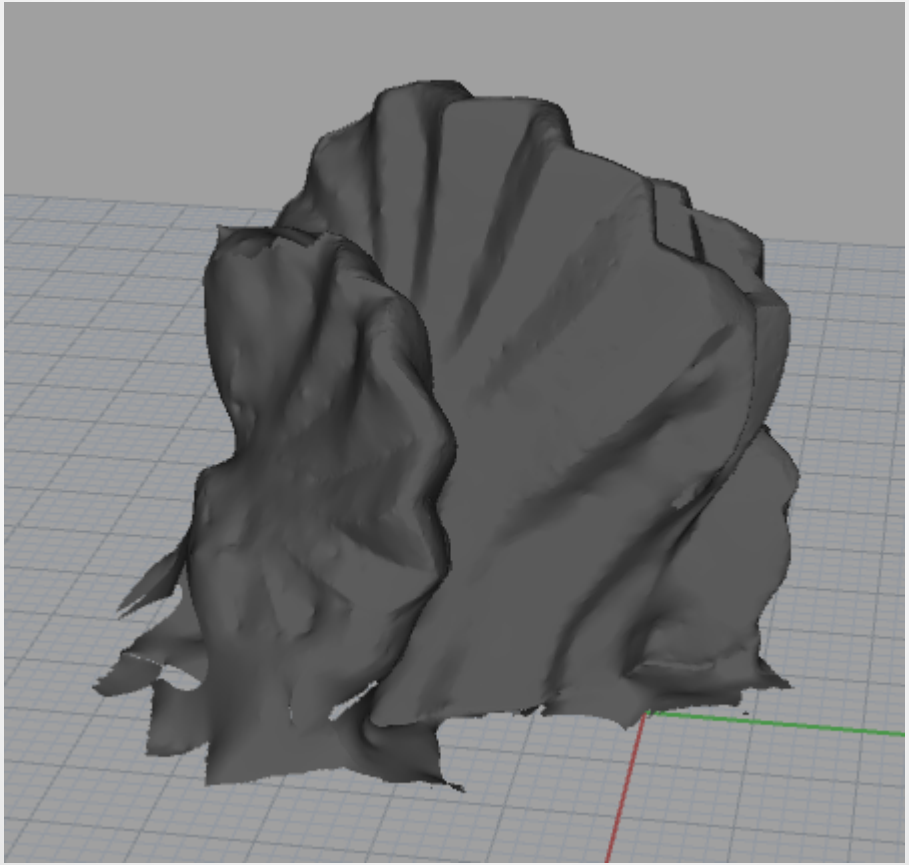
3D Printing in Art and Design

- Began experimenting with different software in the beginning of the 2014-2015 academic year.
- Found it challenging, 2D design software skills such as Photoshop and Dreamweaver were not that helpful.
- Software tested included: SketchUp, Blender, 123D, Autocad 3D, Photoshop, and Rhinoceros.

123D Catch

- Software for phone
- Take multiple pictures to capture a real object and turn it into a 3D model
- Interesting concept, with a learning curve
- Lots of future potential but still has many issues

123D Catch Example



Testing for use in Art Courses

- Sculpture class was the first class where I did a project with students incorporating 3D design.
- It was an optional material in the final project last year.
- In the future I intend to make it mandatory as my own skills grow stronger in the area.

Choosing 3D Software

- Though I used Rhino last year, this will likely change as the software is out of Beta testing and the cost has gone up to about $1000 per lab and $100 (Mac) for one faculty computer.
- Currently has free 90 day trial.
- Will likely switch to one of the other professional programs that are free to education, probably one of the Autodesk products or SketchUp.

The Learning Curve

- Was more difficult than expected even with past design experience!
- Not intuitive to learn.
- Working with the added Z index adds much greater challenge.
- Fun but challenging to learn.
- Videos and tutorials really help.

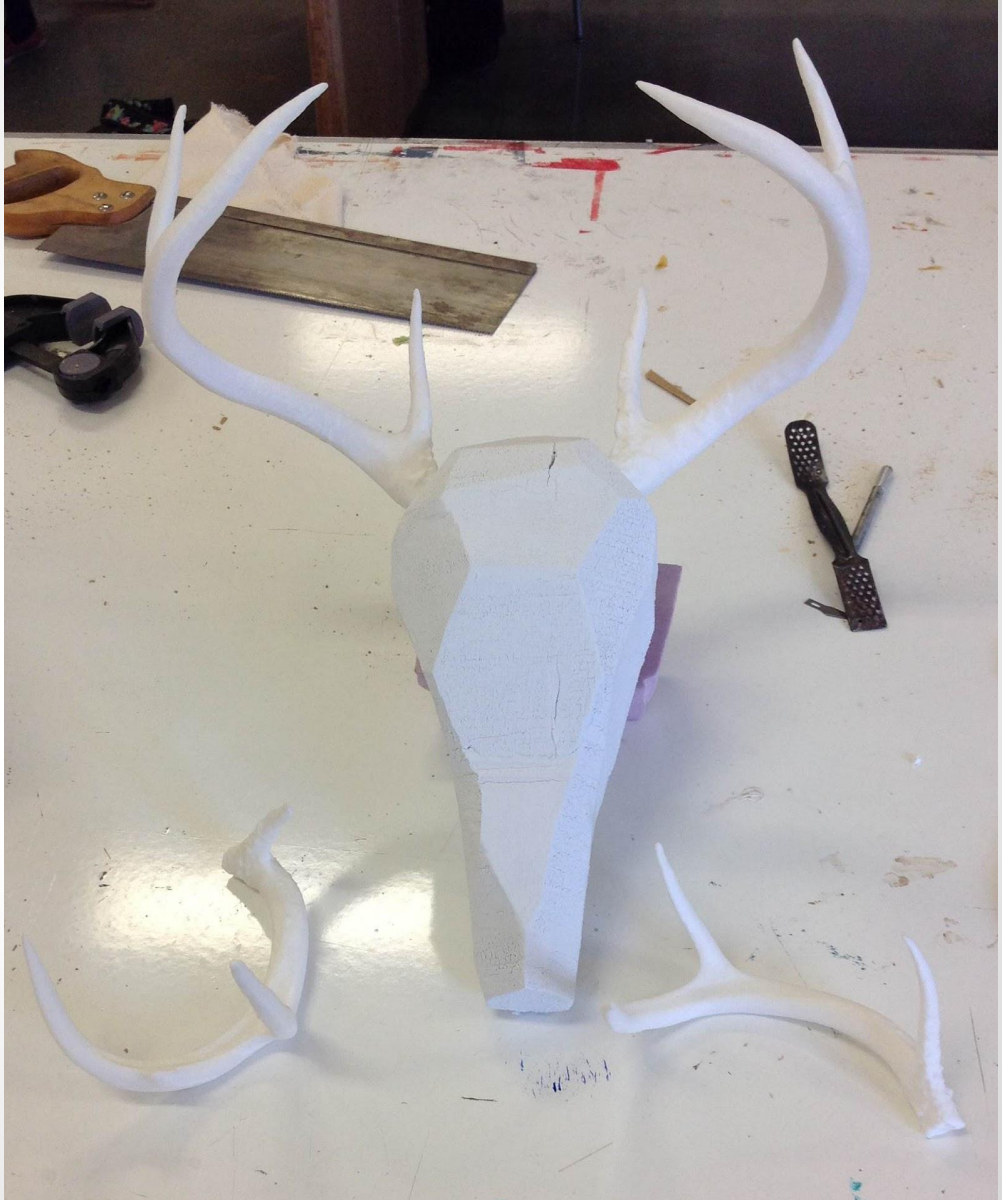
Sculpture Project

- Option as part of final project, conceptual art piece using any materials the student chose.
- 3 students out of a class of 13 chose to do 3D printed parts for the final sculpture.
- All students went through a week of training on the software before deciding.
- I based my lesson and handout on my trial and error and Rhino's training videos.

Sculpture Project

- The students who were more into technology and computers really got into the idea.
- Some studio art students were not interested.
- The students who chose to do it really liked working on it and the end results
- Helps in time management and planning as the printing is slow and sometimes needs to be redone.

Results



Graphic Design

- In the future, probably this year, 3D printing will be incorporated into the design curriculum.
- Currently students do a label design for a package such as a bottle, but with 3D printing they can learn design the bottle as well.
- Many opportunities in the package design field.

Graphic Design

- Offers more skills for future employment
- Thinking about space in a more literal way
- Improves visualization skills
- Growing area in the field

The future in art and design

- Interested in adding to lower level courses such as 3D foundations.
- Engages student's technology interests while teaching new software skills and still creating a tangible 3D object.
- Allows students to create forms (with practice) that would be very difficult in many other media.

Conclusion

- Approaches to explore 3D printing.
  - Concept development
  - Collaborative learning
  - Critical thinking

- Future work skills
  - New media ecology
  - “Prosumer” mindset

Bibliography

Britton, L. I. (2012). A Fabulous Laboratory. *Public Libraries*, 52(4), 30-33.

Russell Gonzalez, S., & Beaubien Bennett, D. (2014). Planning and Implementing a 3D Printing Service in an Academic Library. *Issues in Science & Technology Librarianship*, (78), 7. doi:10.5062/F4M043CC

Segerman, H. (2012). 3D Printing for Mathematical Visualisation. *Mathematical Intelligencer*, 34(4), 56-62. doi:10.1007/s00283-012-9319-7

EDUCAUSE (2012). 7 things you should know about… 3D printing. *EDUCAUSE Resources*. Retrieved on June 11, 2015 from http://net.educause.edu/ir/library/pdf/eli7086.pdf

EDUCAUSE (2013). 7 things you should know about...Makerspaces. *EDUCAUSE Resources*. Retrieved on June 11, 2015 from https://net.educause.edu/ir/library/pdf/eli7095.pdf

Schelly, C., Anzalone, G., Wijnen, B., & Pearce, J. M. (2015). Open-source 3-D printing technologies for education: Bringing additive manufacturing to the classroom. *Journal of Visual Languages & Computing*, 28226-237. doi:10.1016/j.jvlc.2015.01.004

Bibliography (continued)

Thornburg, D. (2014). 7 Hands-On Projects That Use 3D Printers. *T H E Journal*, 41(9), 9.

Johnson, L., Adams Becker, S., Estrada, V., Freeman, A. (2014). NMC Horizon Report: 2014 Higher Education Edition. Austin, Texas: The New Media Consortium. Retrieved from http://www.nmc.org/nmc-horizon/

Makerbot Academy grant program. http://www.makerbot.com/academy

MakerBot in the Classroom: An Introduction to 3D Printing and Design. Retrieved from http://pages.makerbot.com/educational-handbook-makerbot-in-the-classroom.html

MakerBot Replicator 2 Resource Site http://zahncenternyc.wikidot.com/makerbot-replicator-2-overview

Importance of 3D printing in education. Retrieved from http://www.educatorstechnology.com/2013/03/importance-of-3d-printing-in-education.html

Teach a 3D printing course. http://www.stratasys.com/industries/education/educators/curriculum