3D printing scenarios
Submitted for Learning Commons Update, 2/25/2015

This document details possible scenarios of 3D printing use based on conversations by Ray Uzwyshyn and Sarah Naper with campus faculty. The document is not intended to comprehensively detail possible use. Additionally, this document does not document next steps that should be taken to implement 3D printing. Instead, this document provides perspective on possible uses of this innovative technology at Texas State University. Notes from interviews are included at the end of the document.

SCENARIO ONE: Educational Technology
(See interview notes, page 6)

Educational Technology has several courses which directly or indirectly mention 3D printing, including EDTC 5325, Managing Educational Technology; EDTC 5320, Models of Integration of Educational Technology; EDTC 5330, Implementing Technology in Education; and EDTC 5340, Issues in Educational Technology. For her EDTC 5340 class, Dr. Shaunna Smith requires students to develop lesson plans that integrate 3D printing into potential lessons. Their labspace (ED 2132) includes several different low-end 3D printers that students in her courses use throughout the semester. The use of a variety of lower-end printers is deliberate because a less expensive printer would be more likely to be feasible in a public school setting, and having this equipment provides students with awareness of what possible options would be available for enabling successful 3D printing in a K-12 instructional setting. A middle-end 3D printer in Alkek would be beneficial to Dr. Smith's students because it would enable them to experience 3D printing at a more sophisticated level, providing an opportunity to gain awareness of middle-end capabilities and also providing faster printing for class assignments.

In addition to Educational Technology students, Dr. Smith suggested that 3D printing would be an asset to other Curriculum & Instruction students who may not have easy access to 3D printing, enriching their knowledge of possible instructional tools, and even providing students with the ability to create learning objects that would enrich the lessons that they are creating as part of the teacher training curriculum. Dr. Smith suggested such courses could easily include science teaching methods courses, other classes that emphasized integration of technology into instructional methods coursework, or courses that emphasized "problem-based learning." Dr. Smith suggested that due to the significantly different mindset that is needed for successful 3D printing, the ability to learn from mistakes, persist, and embrace failure was an important side lesson that students often learn.

Dr. Smith specifically suggested that attendance at a workshop be required before students/faculty be allowed to use the 3D. This is analogous to a model that ITS has used before allowing users to use various computer applications. Additionally, Dr. Smith was very willing to work with us on this project, helping us to develop training sessions or workshops to help users become aware of how they might use this technology. She suggested that perhaps hosting one workshop per month (e.g., Beginning 3D printing) might help the campus community become aware, or discover, potential uses.

SCENARIO TWO: Art & Design
(See interview notes, page 7-8)

The Art & Design Resource Center (ADRC) has two 3D printers, a MakerBot 2 and a MakerBot 2X, and a Digitizer, which is a 3D scanner. In the same space, they support 2D large-format printing. The space for this equipment is actually a small, narrow room, but no special venting is needed for these machines. Currently, a primary use of these resources is to support metalworking jewelry courses taught by Nicole DesChamps-Benke. As part of her course's curriculum, students are required to complete seven prints within the first month of the course. As part of her instruction, 25 licenses for Rhino software (https://www.rhino3d.com/) have been allocated to computers in Alkek 119 [Note: Jan Carmack helped set-up this software].

The 3D printer can be used to create molds for metalworking, or sometimes the 3D printer creates pieces that are part of a creative work. Art & Design has even used the equipment to create pieces to replace malfunctioning parts of the equipment, or in one case, a piece was printed to facilitate mounting a projector.

Ms. DesChamps-Benke suggested that having this type of technology in the library would be beneficial to a wide variety of students, even outside of Art & Design. She mentioned a former student who got their current job because of his familiarity with this type of technology. She said that 3D printing is "just another tool" that we provide our students, similar to a computer or even a hacksaw.

In addition to a 3D printer being a valuable service for students who did not have access to the Art & Design Resource Center (use of the printer is limited to students in this discipline), DesChamps-Benke and Susan Thompson (lab coordinator) feel that an Alkek 3D printer would be an invaluable back-up solution for them during their "crunch" time. Since individual print jobs can be time-consuming, having an alternative option for students to use would be helpful.

Of the groups that we consulted, Art & Design is the only group that has developed a model to manage costs of a production service. Additionally, they have specific strategies for training student workers to manage this service. The fact that Susan Thompson and Jan Carmack have a positive working relationship could be very beneficial to an Alkek service.

SCENARIO THREE: Engineering/Engineering Technology
(See interview notes, page 9)

Engineering and Engineering Technology have a long history at Texas State of being engaged with three dimensional printing as a means of rapid prototyping. As such, this technology plays a critical role in supporting curriculum, and as disciplines that have an increasingly large presence on the Texas State campus, this is an increasingly significant role.

Traditionally, in engineering, 3D printers are used for rapid prototyping with strong relationships with creating molds for metal casting. Texas State has produced a variety of these types of plastic molds and

plastic objects later cast in metal or used as plastic parts. It is possible that business courses might similarly benefit from the prototyping capability of 3D printers.

Specific courses that utilize this technology include Freshman Graphics, Tech 1311, and Engineering Design Graphics, ENGR 1313. Final projects at various levels are used to create 3D-printed prototypes which allow better critique of form functionality from the standpoint of being able to hold, see, and manipulate a printed object in three-dimensional space. This later equips engineers with a variety of essential skills, including the ability to envision how later assemblage of parts will occur and the ability to identify design flaws in an original model that could not be seen with two-dimensional drawings.

Dr. Sriraman emphasized that Engineering Technology is open to new conceptions of multidisciplinary library connections, which a makerspace would afford. He suggested this type of space would facilitate more interactions between Engineering/Engineering Technology and the Library.

Engineering Technology is not interested in a particular printer but a diversity, or plurality, of printers to give students the option to learn various methodologies.

SCENARIO FOUR: Forensic Anthropology
(See interview notes, page 10)

Anthropology's 3D printing operation was by far the most sophisticated of the group that we visited, with $1.5 million of equipment being employed. Also, the type of 3D printing done in this lab was very different in composition, in that gypsum powder is used to create new models, as compared with plastic filament that is used by other printers that we visited.

In this discipline, 3D printing allows for creation of learning objects that students can handle as they are learning investigative techniques. Additionally, Dr. Wescott described 3D printing as a means of recreating an object that can be examined as part of a research process, when physical access to an object may be restricted. With some criminal investigations or in cases where faculty are called as expert witnesses in court cases, these objects can be increasingly helpful. Also, some research investigations are enhanced by the ability to examine even very minute objects with an enlarged, tangible, version of the original.

It is possible that other research or instructional disciplines will benefit in similar ways. As Dr. Wescott said, "You never know what you can do with it (3D printing technology) until you walk in and say 'Wow! This is what I can do.'"

Anthropology was generally in favor of 3D printers for the Library as a means of exposing a wider number of students from various disciplines to these new methodologies.

SCENARIO FIVE: Geography
(See interview notes, page 11)

Geography is the only discipline that we consulted that does not currently have 3D printing capability. Given that he has not used the technology, Dr. Giordano struggled in identifying potential uses. However, as a GIS faculty member, and hence, likely to be more comfortable with technology, he immediately related to the idea that the technology could create objects that could be used in instruction to facilitate understanding of concepts. Some of the geography subdisciplines that he suggested might benefit include remote sensing, geomorphology, landscaping, and cartography.

One of the desires that Dr. Giordano expressed as an ideal would be the ability to print in multiple colors. Alternatively, if we could not immediately print with multiple colors, there might be a way to deconstruct a map and print different layers and manually overlay them as appropriate, creating a three dimensional object to depict reality on a different scale. Dr. Giordano suggested that ease of use and quality of print output would be other factors that should be considered when selecting the printer.

It is likely that Geography would buy-in to the benefits that 3D technology would afford. However, development of sessions to engage and instruct users seems necessary to facilitate this acceptance.

SCENARIO SIX: STEM Education

In Fall 2014, the Library was approached by a multidisciplinary faculty team that was drafting an NSF Research in Engineering Education (REE) grant. Team members include: Dr. Kimberly Talley (Engineering Technology), Dr. Shaunna Smith (Curriculum & Instruction), Dr. Araceli Ortiz (Curriculum & Instruction), Dr. Vederaman Sriraman (Engineering Technology), and Dr. Leslie Huling (Grant Director for LBJ Institute for STEM Education & Research).

Specific student groups targeted in this scenario include: a) students in the open University Seminar course- *Intro to University Life and Engineering* course who will attend seminars in the Bobcat Makerspace and utilize its resources for design projects; b) students in the courses called *Engineering Design Graphics, Computer Aided Design and Drafting* who attend seminars and increase their levels of creative participation in the Bobcat Makerspace; c) other university students who participate in Bobcat Makerspace activities and seminars through special events and personal interest in making and innovating; and d) pre-service teachers (student teachers) in STEM education courses who attend seminars in the Bobcat Makerspace and utilize its resources for design projects.

In this scenario, the 3D printer, serves as an instructional tool for these specific student populations. In addition, data about usage of the Alkek Library printer becomes a research tool. The intent of the research grant is to specifically research the impact of makerspaces on engineering education with these research questions:"

Q1. To what extent does involvement in a makerspace, as a recruitment and retention tool, serve as a pathway to and through engineering?

Q2. To what extent does involvement in a makerspace affect student learning and STEM professional identity development?

Q3. What engineering instructional approaches can value, build upon, and render meaningful students' prior making and life experiences and thereby boost student success?

Education, Dr. Shauna Smith
1/6/2015
Notes compiled by Ray Uzwyshyn

- The School of Education uses mostly low cost 3-D printers (1-3k) to train aspiring K-12 educators into new pedagogical/technology methodologies. This is used mostly in educational technology methodology courses to expose students to these possibilities.
- By creating various printed objects: creative, utilitarian, personally meaningful, learning is stimulated. The 3D printer challenges students to think mathematically, analytically and creatively in terms of design specifications. The excitement of building actual objects is used to facilitate teaching challenging science (STEM) concepts.
- By creating personally meaningful objects, students desire to learn is spurred.
- Various vendors are interested in having 3D printers for schools as the price point is becoming available to the average consumer (vendor partnership possibility)
- Dr. Smith feels that the 3D printer allows students a mode of personal expression analogous to the printed page in terms of students being able to express and develop their creativity and mathematical/design skills.
- For educators, there are a variety of free open source and mobile apps that allow 3D model building. Dr. Smith mentioned particularly Autodesk 123 Design, Catch (which weaves a model stitching images together), Creature, which allows 3D by node joining creation to various symmetries and Sculpt, a type of 3D virtual clay. Dr. Smith pointed out a number of open source 3D model creation tools available on the market.
- Dr. Smith mentioned Makershed, a 3D printer vendor as a currently approved IT vendor on the IT list for filament.
- For a rollout model, Dr. Smith suggested an analogue in the invention studio model of having faculty/students/potential patrons take an introductory usage workshop in order to be able to use the 3D printer. Tekshop was also mentioned as a method to get students accustomed to equipment.
- In terms of training both student assistants (following a Kinko type model) and faculty educators/experts may be invited to workshop to faculty on multidisciplinary educational/pedagogical uses of 3D printers.
- Dr. Smith also mentioned art and designs use in a sculpture class where modern and traditional styles are meshed. Other Education Faculty members Gayle Dickinson and Dr. Oestreich who teach science methods methodology classes are also possible sources of further information.
- A recommendation was made to pursue the best quality, quickest print possible.
- As a local library example, New Braunfels public library was mentioned.
- Dr. Smith mentioned ‘recursive failure’ as a pedagogical learning technique and the importance of ‘mistakes’ and ‘epic fails’ with 3D printers and how these may also lead to discovery, insight and innovation.
- There are complex as yet unexplored connections with literacy, editing on a page, 3d printing and re-printing with prototypes and models. These methodologies have large room for exploration on a university environment.

Art & Design -- Nicole DesChamps-Benke and Susan Thompson
2/12/2015
Notes compiled by Sarah Naper

The Art & Design Resource Center (ADRC) has two 3D printers, a MakerBot 2 and a MakerBot 2X. The 2X allows for printing of two different colors of filament, but it usually takes twice as long. Both printers allow for printing of free-standing shapes, without support (i.e., the printer printed a link chain, with no manual modification to the shape needed). Additionally, they have a Digitizer, which is a 3D scanner. In the same space, they support 2D large-format printing. The space for this equipment is actually a small, narrow room, but no special venting is needed for these machines.

Nicole is a senior lecturer who uses 3D printing technology to support her metalworking jewelry courses. As part of the curriculum, students are required to complete seven prints within the first month of the course. As part of her instruction, 25 licenses for Rhino software (https://www.rhino3d.com/) have been allocated to computers in Alkek 119 [Note: they have found that Sketch Up files do not translate as well as Rhino]. Susan Thompson is a Lab Coordinator for Art & Design. Art & Design is a Mac environment, but Rhino currently only runs on PCs, so students are actually in Alkek for coursework related to this creation. The 3D printer can be used to create molds for metalworking, or sometimes the 3D printer creates pieces that are part of the creative work. The equipment has even been used to create pieces to replace malfunctioning parts of the equipment, or in one case a piece was printed to facilitate mounting a projector.

Attached is a scan of the ADRC Print Center guide (blue) for students and also the page that they use to calculate payments (yellow). The Center is obviously not trying to make a profit, but would like to recoup costs.

Nicole suggested that having this type of technology would be beneficial to students. She mentioned a former student who got their current job because of his familiarity with this type of technology. She said that 3D printing is "just another tool," similar to a computer or even a hacksaw.

A student worker was also available to talk to me about her experience managing the printing. The center has 3 student workers who work ~20 hours per week. Susan suggested that this really was essential. 3D printing is not self-service, so having a well-trained student worker who can listen to/watch the equipment and make any modifications is really essential. Typically an average job on these machines could take 15 minutes to 2 hours. However, the Center tells students to expect at least 24 hours for a print-out, and if there are a lot of jobs in the queue, they tell students that it might take 48 hours.

The student worker and Susan suggested that learning to work with this equipment is really a hands-on process, but there are a lot of YouTube videos, and maybe some Lynda.com videos, that can make the process easier.

Communicating with students who submit print jobs is really important. If there are problems with the display of the file on the monitor or error messages, getting a screen capture of this information is very helpful in facilitating this communication.

Art & Design seemed very supportive of the Library getting a 3D printer, stating that it would really be helpful to them when it was “crunch” time in their area to have another option to share with students. They also thought the printer would benefit students who were not in their programs. They are very willing to provide follow-up information or help.

Engineering Technology, Dr. Vedaraman Sriraman
12/18/2014
Notes compiled by Ray Uzwyshyn

- There has traditionally been a historical longstanding relationship between the School of Engineering at Texas State and 3D Printers beginning in 1999 or earlier.
- Texas State was one of the first universities in the country to possess a 3D printer for research and prototyping purposes. This type of printer has a long history with synergies to curricular instruction.
- 3D printers are used in many school-of-engineering classes starting from the freshman undergraduate level and including *Freshman Graphics* (Tech 1311) *and Engineering Design Graphics*. Final projects at various levels are used to create 3D printed prototypes which allow better critique of form/functionality from the standpoint of being able to hold, see and manipulate a printed object in 3D space. This later aids in envisioning areas ranging from how later assembly between parts will happen to design flaws in the original model that could not be seen with 2D drawings.
- Traditionally, in engineering, 3D printers are used for rapid prototyping with strong relationships with creating 3D molds for metal casting. Texas state has produced a variety of these types of plastic molds and plastic objects later cast in metal or used as plastic parts.
- The School of Engineering has used many types of 3D printers ranging from Carbon Dioxide Laser beams to FOM printer heads which printed molten plastic by an accretive process from the bottom up. These early efforts began in the late nineties.
- There is a strong digital connection with 3D printers to be able to create rapid prototypes.
- Early 3D printers required huge venting specifications but this has changed. Dr. Sriraman has published on 3D printers for the American Society of Engineering Education and 3D printers are currently an integral part of the engineering curriculum.
- In terms of curricular functions, 3D printers pragmatically develop an engineer's spatial reasoning abilities and their ability to envision and translate a 2D specified object into three dimensions (autographic projection). 3D printers here also aid students in seeing errors or miscalculations in 2D design.
- In the corporate world, 3D printers are considered par for the course and an expectation of any graduating engineer is to have worked with various 3D printers. In later career trajectories these prototypes are used to interact with various non-technical divisions of a corporation: marketing, finance, strategy etc.
- The School of Engineering is open to new conceptions of the multidisciplinary library connections for the Makerspace and would like to be interacting with library more.
- In terms of community outreach Engineering has built prototypes for various stakeholders in the San Marcos/Central Texas service community, with a community service orientation.
- Engineering is not interested in a particular printer but a diversity or plurality of printers to give students the option to learn various methodologies.
- 3D printers from engineering standpoints are used by both manufacturing or mechanical engineers.

Forensic Anthropology, Dr. Daniel Wescott
12/19/2014
Notes compiled by Ray Uzwyshyn

- Forensic Anthropology possesses a large 3D printer and 3D Scanner Set up (Approximately 1.5 million worth of equipment) including 800k for a very large micro CT scanner and a variety of 3D printers and scanners over a large lab-like space.
- The 3D printer is used for facial reconstruction classes, research and forensic-related court cases for law investigation, research and teaching. Currently, Dr. Wescott is involved in a large migrant project for unknown individuals who die while crossing the border in mysterious circumstances. Using a 3D model of the skull helps to both identify and reconstruct facial features.
- 3D printers are also used by Forensic Anthropology to teach human evolutionary phases and examine skulls in prehistoric man with several skull reconstructions of early human skeletons.
- 3D printers allow both the shrinking of large objects to examine better objects and conversely to scale small objects to a human size to similarly examine objects which may be too small for the human eye to appreciate the detail.
- Forensic anthropology is currently printing a 3D landscape near Texas State using both drone technology to flyover and map the landscape and 3D tools to later print the map.
-Dr. Wescott pointed out that there is a steep learning curve with 3D printers as they come in all shapes and sizes, must be connected to various software and have various large computing requirements (terabyte drives) for files depending on resolution wanted and requirements. The recommendation was for a dedicated Human resource component allocated to gathering expertise with regards to printing. There was also a recommendation to purchase a smaller 3D scanner if possible in tandem with the printer.
- Anthropology was generally in favor of 3D printers for libraries for both the Makerspace and exposing a wider number of students from various disciplines to these new methodologies.

Geography, Dr. Alberto Giordano
1/5/2015
Notes compiled by Ray Uzwyshyn

- The 3D printer could be used in remote sensing, geomorphology, landscape printing, cartography, landform maps.
- Dr. Giordano would like more specific information regarding the 3D printer, how it is used elsewhere on the university and new possibilities of Makerspaces to be able to circulate to their faculty and make better recommendations.
- Geography Departmental Computer Staff should be consulted with regards to 3D printer directions as tech point persons for their department.
- As a teaching tool would be a main curricular use of a 3D printer for geography – Dr. Giordano does not see any overly commercial/creative purposes at present.
- Geography is one of the largest majors in the university and is interested in technology and applications in the labor force (Applied Geography Program)
- Factors for the 3D printer would be ease of use, quality of printer, color to be able to print different strata on a relief map
- A teaching function/technological support aspect for the 3D printer would be primary
- Freeman ranch came up by Geography as a model that geography would like to print. To note, Forensic Anthropology is also currently pursuing this type of mapping with Freeman ranch with their 3D printer.

ADRC Print Center

JCMitte Building, Room 3102A
512-245-8470

The Print Center is a service bureau for Art and Design faculty and students.

Payment

- Try to predict how much printing you will need for a project or for the semester.
- Students must pre-pay for prints at the JCK cashier's window (cash only).
- Bring your receipt back to the ADRC and they will set up your account.
- A record of your balance will be kept at the Center.
- Faculty who wish to use the Print Center must make arrangements with the School Director.

Printing your documents

- The Print Center staff will not prepare or edit your files for you.
- They will not rasterize or outline your type.
- Any file presented in a PDF format will be printed from Photoshop.
- Our Epson printers are set up in sRGB. The printers are set to print from this profile using the papers we carry.

Printing Options

EPSON R3880

8.5" x 11"	$3.00 Premium Presentation Paper (Matte) $1.50 if you provide paper, Epson Inkjet (Matte) only
13" x 19"	$7.00 Premium Presentation Paper (Matte) $3.50 if you provide paper, Epson Inkjet (Matte) only

EPSON STYLUS PRO 7800 *(for oversized printing)*
Doubleweight Matte paper only, $.04 per square inch, provide borders on all sides.
Example: One 16" x 20" print would be calculated as: 17" x 24" x $.04 = $16.32

- For best results on the 7800, use Photoshop files.
- Export InDesign or Illustrator files as a PhotoShop EPS and open them in Photoshop to rasterize them.
- Drag the file to a 24-inch wide Photoshop document using the height of your file plus 1 inch.
- Leave a .5 inch border at top and bottom of your image and 1 inch on the sides.
- Save as a TIFF or PSD.

In all cases, you will get the best color results by exporting your files from InDesign or Illustrator and printing from Photoshop in RGB.

File transfer options
- Flash Drive
- CD/DVD
- Drop Box

To access the ADRC_Print Server drop box from a Mac in the Mitte building, follow this path:
Desktop > Go > Network > ADRC_prints here > Connect as >
name - *artuser* / **password** - *print* > Connect > artuser > Public > Drop Box

Naming Files
Label files with last name and date e.g., *picasso_10_28_15.psd*

A work order form will need to be filled out with the details of the print job.
See other side of sheet for pre-payment procedures.

Production Notes
- Depending on time work is submitted and the actual time needed to process work, please preplan as we can not guarantee same day work. It is helpful to speak with us for a realistic turnaround on your project.

- Finished work will be ready for pickup at the ADRC front counter.

ADRC
Art & Design Resource Center

Operating Hours

Monday - Thursday	8 am - 10 pm
Friday	8 am - 4 pm
Sunday	4 pm - 8 pm

ADRC Telephone Contact
512-245- 8470

Date: ____/____/____

Name: _____ Initials

Email: _____/ Phone: _____

2D

EPSON STYLUS PRO 3880

	Size	Quantity	TOTAL
❑	8.5x11	_____ x $1.50 (Image fits in a 4.25 x 4.25 box)	$_____
❑	8.5x11	_____ x $3.00	$_____
	❑	$1.50/paper supplied*	
❑	13x19	_____ x $7.00	$_____
	❑	$3.50/paper supplied*	

*paper supplied must be an Epson Matte Inkjet Paper

Second side print: *Charge for cost of front and 1/2 cost for back*..... $_____

EPSON STYLUS PRO 7800

❑ 24x_____ = _____x $.04 per square inch ..... $_____

Calculate as follows: 24 inches x the height of the file + 1 inch x $.04

<Example for a 16x20 print: 17 in x 24 in x $0.04 = $16.32>

Paper Type **Crop Marks?** _____

_____8.5x11 Singleweight Matte

_____8.5x11 Heavyweight Matte

_____13x19 Singleweight Matte

_____Epson 7800: Doubleweight Matte only

TOTAL $_____

GRAND TOTAL $_____

2D Comments/Instructions

Initials

File Name/s:

Initials

_____

Receipt of Prints Signature

Amount remaining in account:

Date: ____/____/____

Name: _____ Initials

Email: _____/ Phone: _____

3D

1. SET-UP __.*stl format* / __.*obj format* / __.*thing format*
within 10 minutes*, print ready for extruding single/$1; dual/$5.....$_____

***additional time**: $3.00 per 15 minutes for custom adjustments*.....$_____

2. MATERIALS
_____ **grams x** _____ **cost of spool* ÷ 1000 ft roll**..... $_____

____* $50.00 PLA Natural Color
____* $55.00 PLA True Colors: __Red __Purple __Blue __Yellow __Orange __Black __White
____* $70.00 PLA Translucent Colors: __Red __Purple __Blue __Yellow __Orange __Green
____* $140.00 PLA Glow in the Dark

____* $50.00 ABS Natural Color
____* $55.00 ABS True Colors: __Red __Purple __Blue __Yellow __Orange __Black __White
__Gray __Green
____* $70.00 Dissolvable

3. PROCESS

_____ **minutes run time x $0.15 cost/minute** ..... $_____

TOTAL $_____

3D Comments/Instructions

Initials

File Name/s:

Initials

_____ Amount remaining in Account:
Receipt of Work Signature