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Abstract: Many academic libraries are adopting 3D printing programs and researching, writing, and implementing policies for these programs. This article analyzes the content of 50 academic library 3D printing policies looking for commonalities. Five major themes emerged from the analysis: the policy's purpose, potential users of the 3D printers, 3D printing procedures, the acceptable uses of the 3D printers, and user privacy considerations. This article provides a breakdown of these five major themes.

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In *Fabricated: The New World of 3D Printing,* Lipson and Kurman (2013) state, "Like the magic wand of childhood fairy tales, 3D printing offers us the promise of control over the physical world" (p. 11) . The seemingly magical property of three-dimensional (3D) printing is one of the draws libraries have to implementing the service, but there is a lot of work involved in actually bringing 3D printers into use at an academic library. Perhaps one of the most important tasks library staff will embark on in this process is developing a policy. A well-worded and constructed 3D printing policy can protect not only the library, but the users as well. This article examines 50 academic library 3D printer policies to help determine the wording, content, and themes that are emerging from these policies.

Literature Review

3D printing, sometimes referred to as additive manufacturing or rapid prototyping, involves the successive building of material in a shape predetermined from a computer file (Griffey, 2014). Charles Hull, an engineer, is credited with developing the idea of 3D printing. The National Inventor Hall of Fame inductee's method was developed in 1985 and involved using UV light to cure and bond photopolymer resins (National Inventors Hall of Fame, 2016). Several individuals, groups, and companies, using this technology, have created different types of 3D printers useful to everyone from hobbyists all the way to major corporations and government agencies. There are several types of 3D printers now, and academic libraries are increasingly acquiring them for patron use (Uzwyshyn, 2015).

Several reasons address why 3D printers are a good fit for academic libraries. Gonzalez and Bennett (2016), in their book *3D printing: A practical guide for librarians,* lay out several of these reasons. A large reason is that some libraries have the space and capabilities for training patrons about 3D printing. Libraries also offer a unique space and tradition of collaboration which is beneficial to learning new technologies. Libraries have long been on the forefront of providing their users access to technologies such as computers, printers, copiers, and the Internet. 3D printers can be used in all kinds of academic endeavors and can be methods of visualizing information and data in new ways. Many

departments on college and university campuses have 3D printers, but a library is a way to offer them to the entire campus population and, in many cases, the surrounding community (Chen, 2012, September 17). It seems a natural step that 3D printing would be welcome in all types of libraries including academic ones.

Many articles have been published outlining the steps taken to implement 3D printing services into an academic library (Gonzalez & Bennett, 2014; Groenendyk & Gallant, 2013; Moorefield-Lang, 2014; Nowlan, 2015; Pryor, 2014; Scalfani & Sahib, 2013). Among the steps are purchasing the equipment, finding a suitable location, training staff and students, developing procedures, and writing a policy. Several of these articles discuss the importance of developing a library policy for 3D printing, and some go into detail about developing policy (Gonzalez & Bennett, 2014; Nowlan, 2015; Pryor, 2014; Scalfani & Sahib, 2013). Establishing a thoughtful policy is an important step in the process of coordinating a 3D printing program anywhere, including an academic library. A good policy lays the framework for using the technology, and it outlines the expectations of the library and the patron alike.

The American Libraries Association (ALA) has been providing guidance to libraries when it comes to 3D printing and in particular ways to develop a working policy. According to Jones (2015), along with advocacy and professional and leadership development, determining information policies is one of the "key strategic areas for the profession" (p. 37). In September 2014, ALA issued a press release announcing the launch of "Progress in the Making", an educational campaign to assist libraries in the challenges of adopting 3D technology (American Library Association, 2014, September 29). The tipsheet discussed such issues as the legal implications of 3D printing, particularly copyright law, and intellectual freedom concerns. A link to a sample copyright warning notice developed by Tomas Lipinski of the University of Wisconsin-Milwaukee School of Information Studies was included (American Library Association, 2014, September 29).

Wapner (2015), an information policy analyst for the ALA Office of Information Technology Policy (OITP), authored a report discussing the history of 3D printing, the economic implications, and some of the public policy considerations inherent in the topic. The report goes further than the previously

released tipsheet by giving examples and focusing more on the potential individual issues. Much of the report discusses intellectual property issues that can arise from 3D printing, including copyright, trademark, trade secrets, trade dress, and patents. Safety and product liability issues are also addressed. The report discusses the fact that libraries and librarians will play a role in adopting public policy concerning 3D printing and the profession needs to develop, "… a set of best practices to guide patron printing behavior" (Wapner, 2015, p. 15).

Also included in OITP's report was a special section by Deborah Caldwell-Stone, the Deputy Director of the ALA Office for Intellectual Freedom (OIF). Caldwell Stone counsels against adopting 3D printing policies that would arbitrarily place limits on a user's constitutionally protected intellectual freedom and expression. She makes clear that there can be reasonable limits on the types of objects that are printed, in particular as they apply to safety, equitable access, legality, and intellectual property rights (Caldwell-Stone, 2015).

Later that year, the Director of OIF, Barbara M. Jones, authored a bulletin focused on freedom of expression and library policy statements (Jones, 2015). In the bulletin, Jones mentions that staff within the association are working on a "user-created content policy" (p. 37). She further states that a draft has been developed with the hopes of gaining approval from ALA's membership (Jones, 2015) Four key parts are outlined for establishing a productive 3D printing policy:

- Keep any policies positive and forward looking
- Keep the policy simple
- Outline any procedures
- Provide some definitions.

Jones also mentions that a policy should include access for all, it should not interfere with First Amendment rights, and it should address user privacy considerations (Jones, 2015).

In the same issue of the *Bulletin of the Association for Information Science and Technology*, Chan and Enimil (2015) delve further into copyright topics that should be considered when libraries engage in

3D printing. In addition to laying out how copyright law applies to 3D printing, the authors mention how copyright should play a role in every 3D printing policy. The policy should not be based on fear, but should address risks to the library and to patrons while emphasizing the benefits of 3D printing and encourage its creative uses. Included in the paper is a sample 3D printing policy which focuses on five elements:

- use of the printer

- assessment

- cost of printing

- the procedures of picking up a printed object

- access to the printer (Chan & Enimil, 2015).

3D printing in academic libraries is relatively new, and not a lot of literature has been published on the content of academic library 3D printer policies. Moorefield-Lang (2015) looked at makerspace acceptable-use policies in both public and academic libraries. Makerspaces can include 3D printers among the technology offered, but that study was not centered solely on 3D printing policies. Moorefield-Lang (2015), in her study of 24 makerspace policies, concluded that makerspace acceptable-use policies focused on introducing patrons to the makerspace, familiarized users with the technologies in them, and set out rules and expected behaviors.

At this time, there are no standard policies for 3D printing in academic libraries. Sample text is available, as in the paper by Chan and Enimil (2015), but no policy language has been adapted or approved by the ALA or other organizing body.

Methodology

Fifty academic library 3D printer-specific policies were used for this study. The policies were gathered by performing an online search looking for 3D printer policies and academic libraries. To simplify the analysis, only 4-year academic libraries within the United States were used. The study does not include community colleges, trade schools, schools outside the United States, or public and special

libraries. The policies also had to be freely available online through the library's website. This study looked only at the policy document or policy section of the library's website. Any information that could be interpreted as policy but was not in these sections or documents was not used. For example, if the types of individuals allowed to use the printer was included in a video or a PowerPoint presentation instead of the policy section of the website, that information was not considered.

Qualitative content analysis was performed on the data, looking for both content and emerging themes. According to Krippendorff (1989), content analysis, "…seeks to analyze data within a specific context in view of the meanings someone – a group or a culture – attributes to them" (p. 403). This research involves identifying phrases, terms, and ideas with the same meaning and patterns.   The general "Mechanics of Coding" laid out by Saldaña (2009) were used. These included pre-coding the policies with preliminary jottings, developing a code list with descriptions of the codes and content, and then manually coding the policies. The policy documents were coded in their entirety and reviewed several times.

Results

By analyzing the 50 policies, five main themes emerged: the purpose or mission of the 3D printing program, the potential users, the procedures, acceptable use, and privacy considerations.

Purpose or Mission

The stated purpose of having a 3D printing program was analyzed. In these policies, the purpose was also referred to as mission, mission statement, or no specific title, but all conveyed the meaning of a purpose. Of the 50 policies, 23 included a purpose or mission-type statement. Examples of 3D printing-program purposes included offering new and emerging technology to the community, promoting student success, and nurturing creativity and discovery with state-of-the-art tools.

Users

Each library must determine who has access to its 3D printers. Of the 50 policies, 41 noted who has access to its 3D printers. Some libraries allow only currently enrolled students to use the 3D printers;

some allow students, faculty, and staff to use the 3D printers; and others allow anyone to make use of the technology, including non-affiliated community members (see Table 1).

[place Table 1 here]

Priority of Use

In addition to who can use the 3D printers, the priority of use is a common component among the policies. This issue deals with the order that prints are taken, processed, and completed. As Table 2 shows, everything from first-come, first-serve to a dedicated priority list can be found in the policies; 21 policies mention some type of priority list or specifically state that there is no priority to the printing. Of those 21, 13 give priority to prints relating to classwork, academic use, or research.

[place Table 2 here]

Procedures

There are many procedures that go into running a 3D printing service at an academic library, from how to process a 3D print request to how much to charge for the prints to who actually sets up and prints the objects. Within these policies, these libraries focused on four major procedural points: who performs the printing, the price of 3D prints, how the pickup of models are handled, and concerns and issues over model quality.

Who does the printing? Not every library allows everyone to physically use the 3D printers. Some are more restrictive than others as is seen in Table 3. Of the policies reviewed, 28 noted who actually can physically use the library's 3D printer. Some libraries allow users to be trained and print themselves, some require staff supervision to do the printing, and some allow only library staff members to have hands-on access to the 3D printers.

[place Table 3 here]

Pricing. Of these policies, 38 mention the cost to the user for 3D printing at the library. In the various policies, there are a variety of pricing structures and ways to determine the cost of any objects printed. This is demonstrated in Table 4. The costs ranged from free, a cost per weight, or a charge for the actual printing time. Of the 50 policies, nine offered free 3D printing, with three others having a

variation on free printing. One library offers free printing for university members and charges only guest users. Another library offers free printing only for class assignments, and another library offers free printing only up to 15 grams in weight. Some library policies, 26, calculate the cost of an object by actually weighing the 3D printed object or using a software program to calculate the estimated weight and then charging the user a cost per gram. The amount charged per gram ranges from $0.10 per gram to $0.25 per gram.

[place Table 4 here]

Pickup. When the 3D printing is complete, the user must retrieve the finished object. Some policies, 16, speak to issues with picking up a completed model. Both the time period an individual has to pick up the model and who may retrieve the model are discussed. Nine of the policies make note that they require the individual who placed the request to be the one who actually picks up the finished print at the library. Some policies require the user picking up the model to show a valid form of identification, while others are silent on that issue. The time allowed to pick up a model before they are destroyed, discarded, or become the property of the university varied from 5 to 30 days and was specified in 16 of the policies (see Table 5).

[place Table 5 here]

Quality. Warning potential users about the quality of 3D printing was mentioned in 22 of the policies. Since 3D printing is a relatively new technology to most people, users are often unaware of what 3D printed objects look like. Often, layers are visible, or there are bumps and irregularities. Also, many structures with overhangs must be built with support structures attached. Removing supports can affect the level of quality of a print. Warnings like these, along with notices that not all objects can be printed well were included in the quality sections of some policies.

Acceptable Uses

Many of the policies include sections discussing what is considered acceptable use of the library's 3D printers. These sections outline what can and cannot be printed on the machines. Below are several distinct themes that emerged from analyzing the 50 policies.

Sample Text. Of the policies reviewed, 19 included sections that directly mirrored parts of the "Sample 3D Printing Policy" offered by Chan and Enimil (2015). This sample text mentions four main areas prohibiting users from 3D printing, including items that are prohibited by law, cause safety issues, are obscene or inappropriate, or infringe on another's intellectual property rights; 19 of these policies include the exact language from section one of the sample text. The section was used word for word in 13 policies, while six of the policies omitted or altered small parts. These changes involved adding in additional policies that must be obeyed or removing the obscenity section.

Lawfulness. A question that may be posed to library staff working with 3D printers is whether unlawful things may be printed at the library. Legality and the lawfulness of objects being printed on the library's 3D printers were addressed in 32 of the policies. Of the 19 policies that pulled text directly from part of the sample policy, all included the phrase that nothing could be printed that is "Prohibited by local, state or federal law" (Chan & Enimil, 2015, p. 29).

Student / University / Library Codes. In addition to refusing to print anything that is illegal or unlawful, several of the policies went a step further. They added that users of the 3D printers must abide by additional rules, codes, and policies. Nine of the policies specifically mentioned other rules governing 3D printer users. These included student-conduct codes, university rules and regulations, and library-specific conduct codes.

Safety. Safety was mentioned in 33 of the policies. These specific mentions of safety revolved around whether the object printed was safe, not whether physically using the machines was a safe process. These were either direct references to users not being able to print anything that was unsafe to the public to more general references that users could not print anything that might be harmful or dangerous. The sample text found in many of the policies directly addresses safety, and each policy that used the sample text kept the part about safety in the policy.

Weapons. Of these policies, 11 included a ban on firearms or weapons in general. These policies stated either specifically that firearms were banned or more generally that weapons of any kind were not to be printed on the library's 3D printers. Six policies mentioned that weapons were banned

from campus and therefore were not allowed to be printed, while others gave no further qualifying information.

Obscenity. Another point many of the policies made was that obscene objects or objects that were deemed inappropriate for a library setting were not to be made with the library's 3D printers; 19 of the policies addressed this point. Sixteen of the policies used the language addressing this issue found directly in the sample text, "Obscene or otherwise inappropriate for the Library environment," (Chan & Enimil, 2015, p. 29). The other three policies that did not use the sample text dealt with the issue of obscenity by either addressing the word obscenity itself or the ideas of printing pornographic or inappropriate items.

Intellectual Property. The topic that was included most frequently in the policies, was intellectual property rights. Of the 3D printing policies analyzed, 40 addressed this topic in some fashion (see Table 6). These intellectual property rights include copyright, trademark, or patent issues. In addition to addressing various intellectual property rights, eight of the policies included a separate copyright notice provision. The eight did not use the same language in the copyright notice, but each referred specifically to the copyright law of Title 17, United States Code.

[place Table 6 here]

Right of Refusal. In the context of these policies, the right of refusal refers to library staff members having the option to refuse a 3D print request for any reason. It does not refer to the phrase "right of first refusal" found in copyright law. Of the policies, 31 included a right-of-refusal notice somewhere in them. The sample policy includes language about the university reserving the right to refuse requests, and 15 of the 19 policies using that sample text mirrored the language about refusals.

Commercial Uses. Two policies made clear that any 3D printing done at the library was for non-commercial use only. Both policies state that anything 3D printed at the library are not intended for commercial purposes and are not to be resold.

Privacy

Only two of the policies addressed the issue of privacy. One policy informed potential users that the 3D printers were on public display, and patrons could potentially view objects being printed within the library or other venues. The other policy involved photographing the finished objects. This policy gave users the option of submitting a picture of their 3D print and outlined the library's procedures and policies for doing so.

Discussion

Many libraries are embarking on the process of crafting and revising 3D printing policies. What is being included and emphasized in these policies is a question that other libraries and other campus departments can look to when generating their own policy. By analyzing the 50 policies, one is able to surmise what is important to the libraries and what 3D printing-related topics library staff feel will need to be addressed. According to the analysis, the issues most often addressed in these 50 3D printing policies can be sorted into two separate concepts: the procedures of 3D printing, and what is acceptable to print. As for the procedures, the price of printing, who is able to use the printers, and who actually performs the printing were frequently discussed. As far as what is acceptable to print, the policies discussed legality, safety, and intellectual property issues frequently.

It makes sense that these issues would be documented by academic library policies. They are issues important not only to libraries, but to actual users. Individuals want to know if they are allowed to use a library's 3D printer, how much it will cost them, and how they will go about doing it. They also want some guidance about what they can and cannot print. Conversely, a library needs to protect itself and is interested in addressing potential liability issues before they occur.

The price of printing is documented in several policies because of the costs associated with 3D printing, including the costs of the machines, staff time to run the program, and supplies such as plastic filament or resin. These costs sometimes must be passed down to the users. Libraries using 3D printers can be in very different financial situations. Some libraries may purchase the equipment outright, some may receive donations of equipment, and some may have been awarded grants. Depending on the types of 3D printers the library has, the medium they print in may vastly differ in price. A roll of plastic

filament for some printers may cost $20 while resin for another type of printer may cost hundreds of dollars. Also, some grants may demand the library offer free 3D printing, while libraries not receiving financial support may need to use a cost-recovery system of payment.

There was also variety among the libraries studied when it comes to other procedures, such as who may use the printer, who physically prints objects, and the printing priority. There may be specific reasons for who can use the machines including grant requirements, university procedures, and staff-time allocation. Some libraries are not set up for patrons to physically use the printers, while others are. Many libraries have dedicated spaces with access to the public, but other libraries do not have the room or staffing to keep 3D printers in the open and accessible to the public for printing.

The legality of objects printed is an important consideration for libraries. Printing gun parts, duplicate keys, and ATM skimmers are among potentially unlawful objects that might be requested by a 3D printer user (Hoy, 2013). Laws and codes must be considered when drafting a 3D printing policy, including library and university policies, municipal regulations, state laws, and federal legislation. Each library is not bound by the same regulations. Some may have stricter laws to follow, while others may have contradictory regulations to follow. Lawfulness of an object is also not always a simple determination. A 3D printing policy that is too specific in terms of what can and cannot be printed can be problematic. Laws and interpretations of laws constantly change. Jones (2015) suggests that too many policies are overly specific and do not use proper terms of law. She suggests policies should be simple and that phrases like "illegal activity is prohibited" (p. 38) covers a multitude of infringing behaviors.

A subissue of legality entails printing weapons. Much has been written about 3D printing and weapons, specifically firearms (Blackman, 2014; Lee, 2013; Simon, 2013; Tran, 2014; Walther, 2015). Media stories appear regularly discussing 3D printed gun parts (Bilton, 2014, August 13; Ferguson, 2013, May 7; Lorenzo, 2013). Slightly over 22% of the policies made special note of weapons or firearms being banned. This does not mean that the rest of the libraries allow these objects to be printed. As above, many of the libraries included language banning illegal activities or activities contrary to university and library policies. According to legal scholars, the legal status of 3D printed firearms is

unclear (Thierer & Marcus, 2016). There may be university or library codes and policies banning any type of weapon on campus which likely would also ban 3D printed parts for a weapon.

ALA's OIF stresses that libraries should not infringe upon free expression when writing 3D printing policies. Caldwell-Stone (2015) states that library 3D printing policies, "…should not be used to bar users from designing and creating lawful items simply because they may cause controversy" (p. 9). Many of the policies include language similar to that found in the Chan and Enimil sample text, which does not permit using the 3D printer to create "Obscene or otherwise inappropriate for the University environment." There may be some First Amendment issues with this language depending on the actual object being printed and the specific library (Minow, Lipinski, & McCord, 2016).

Intellectual property rights are found in most of the policies. Libraries have a long history of protecting and working with intellectual property rights such as copyright. 3D printing is just another extension of this work. Copyright law and other IP laws such as trademark and patent law may be issues to consider when deciding who does the actual printing. The liability could hinge on principles similar to those used with photocopying items in a library. Legislatures and courts may take up these issues eventually, leading to policy revisions. The California state legislature introduced a bill calling for warnings to be posted in public libraries about the misuse of 3D printers (Millsaps, 2015, April 17). That warning text included intellectual property laws. The bill was not voted on and did not leave committee, but it and similar bills may eventually be enacted (Millsaps, 2015, April 17).

An area that is mostly missing from any of the policies is user privacy. Patron privacy is an essential element of academic libraries. An ALA interpretation of the *Library Bill of Rights* states, "The library profession has a long-standing commitment to an ethic of facilitating, not monitoring, access to information" (American Library Association, 2006, para. 7). Some of the 3D printing-related literature from ALA addressed the need to be cognizant of privacy concerns, but these two areas were not directly addressed in most of the policies. Some libraries may already have extended their existing privacy policies to cover 3D printing, so they do not feel the need to include it in another policy. This is one area that future policy drafters and those revising their own library's policy might want to contemplate.

Library staff should investigate any privacy concerns that arise from 3D printing and see if these concerns are already addressed or need to be incorporated into the 3D printing policy itself.

Currently, there is no policy adapted by the ALA or another organization for libraries engaging in 3D printing. Most likely, there is no one-size-fits-all policy that would meet the needs of every academic library. Each institution has its own unique patrons, campus policies, and procedures. States also have differing laws that libraries must be aware of and account for in their policies. There are some common issues that arise, however, and this can be seen in the many libraries using the sample text provided by Chan and Enimil (2015).

Conclusion

The policies, regulations, and oversight of 3D printing in academic libraries will continue to be a topic of discussion. Analyzing these 50 academic library 3D printing policies shows common themes and topics that are emerging. Procedures and acceptable uses are the two major categories of topics being included in the policies. It also appears that many libraries are basing their policies on sample texts and the policies of other libraries. More guidance will be available as the service becomes more widely adopted, and additional issues will emerge that will need to be addressed.

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Table 1. The number and percentage of library 3D printing policies describing the particular types of individuals allowed to make use of library 3D printers.

Types of Individuals	Number of Policies	Percentage of Policies
Students only	1	2%
Students and faculty only	2	4%
Students, faculty, and staff only	19	38%
Students, faculty, staff, and affiliates / library card holders	7	14%
Anyone	12	24%
Policy is silent on the issue.	9	18%

Table 2. The number and percentage of library 3D printing policies outlining different strategies for determining the order of priority given to users of the library's 3D printers

Priority Order of Users	Number of Policies	Percentage of Policies
Prints for coursework, academic, and research reasons get first priority.	13	26%
First come, first served	5	10%
Students, faculty, and staff have priority over the public.	4	8%
Policy was silent on the issue.	28	56%

Table 3. The number and percentage of library 3D printing policies describing who is actually allowed to print 3D printed objects at the library.

Individuals Allowed to Physically Use the Library's 3D Printers	Number of Policies	Percentage of Policies
Only library staff members	31	62%
Users who have been trained	8	16%
Users with supervision	2	4%
Policy was silent on the issue.	9	18%

Table 4. The number and percentage of library 3D printing policies addressing whether there is a cost for using the library's 3D printer.

Costs to Users for 3D Printing	Number of Policies	Percentage of Policies
There is a cost to print.	26	52%
All 3D prints are free.	9	18%
3D prints are free to university members only.	1	2%

3D prints for coursework are free.	1	2%
3D prints are free up until a certain weight and then there is a charge.	1	2%
Policy was silent on the issue.	12	24%

Table 5. The number and percentage of library 3D printing policies addressing the length of time a user has to retrieve their 3D printed object at the library

Amount of Days to Pick Up a 3D Printed Model	Number of Policies	Percentage of Policies
5 days	1	2%
7 days	4	8%
14 days	9	18%
30 days	2	4%
Policy was silent on the issue.	34	68%

Table 6. The number and percentage of library 3D printing policies mentioning various intellectual property issues

IP Type Mentioned	Number of Policies	Percentage of Policies
IP mentioned generally	3	6%
Copyright law	37	74%
Trademark law	23	46%
Patent law	23	46%
Policy was silent on the issue.	10	20%