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3D PRINTING AND SCANNING: NEW WAYS TO ENGAGE WITH STUDENTS AND RESEARCHERS

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Abstract
Modern academic libraries are always looking for new ways to engage with researchers and demonstrate their relevance and value. To this end, the University of Oxford's Bodleian Libraries' strategic plan states that one of its main goals is to "Develop digital services that benefit research, teaching and learning." One novel digital service recently launched at the Radcliffe Science Library is a 3D printing and scanning service. The threefold aim of this service was to demonstrate and expose students and researchers to these new technologies, to provide them with easy access to this technology to allow them to explore its potential for their research, and to offer 3D printing to classes and courses being taught at the university. This paper discusses the motivations for creating this service, how the service was developed and launched, what the response was, and what trends were determined in its usage. Most notably it was found that students and researchers discovered novel ways to use the technology, from creating teaching aides to visualising research data for dissemination to wider audiences. The authors conclude by discussing the effectiveness of providing 3D printing and scanning services in academic libraries to meet strategic priorities and give librarians an innovative avenue to engage with academic departments, while providing added value to both students and researchers.

Keywords: 3D Printing, 3D Scanning

Introduction

The Radcliffe Science Library (RSL) is a busy academic library which supports both researchers and students studying science at Oxford University. It is part of the wider Oxford Bodleian Libraries group and as such belongs to the largest academic library system in the UK. Although there is still significant demand for 'traditional' library services (for example, book lending, provision of study spaces, photocopying, document supply, etc.), library management is acutely aware of the need to diversify services to accommodate the changing needs of users and ensure the library remains a key player in the academic life of the university.

As a science library, the RSL is used to dealing with a technology savvy clientele who have readily (although not universally) embraced e-journals and e-books. Opportunities have been created here for staff to teach users how to navigate electronic resources. Subject Librarians regularly provide information skills training in database searching, reference management and bibliometrics. Similarly, changes in Open Access and data management requirements by major UK research funding bodies have led Subject Librarians to provide practical guidance in complying with the new rules. Developing these services has largely been reactive; the motivation for building them being driven by changes in the nature of collections or funders' policies outside the library's control. However, the RSL has also pursued a deliberate, proactive strategy of bringing new, often expensive, technologies into the library for readers to explore. The library has introduced innovative new services that have surprised and engaged readers. Past examples of this strategy include 'Test Drive an e-reader' where the RSL purchased and then lent several early generation Amazon Kindle and Sony e-reader devices. When iPads became available an iPad2 device was lent to readers pre-loaded with a range of productivity and science apps. These projects provided access to new technology and acted as an opportunity for the library to gauge interest in these devices. They have also helped to ensure that librarians themselves stay up-to-date with emerging technologies and maintain an awareness of the new ways in which readers consume information.

The RSL is now providing 3D printing and scanning services to users as another proactive strategy to offer cutting-edge technology for readers to learn and experiment with. The remainder of this paper will discuss the reasons for selecting 3D printing as the latest service to offer readers, how the service was developed and its impact.

What is 3D Printing?

3D printing allows the production of physical objects from 3D computer models (Prince, 2014). Models can be created from scratch using a CAD (Computer Aided Design) application, digitally scanning them from real-world objects or downloading them from online design repositories such as Thingiverse ('MakerBot Thingiverse', n.d.). A wide variety of objects can be produced, from art works and toys to medical prosthetics (Lipson & Kurman, 2013; Warnier, Verbruggen, Ehmann, & Klanten, 2014). The power of 3D printing lies in the speed and cheapness with which highly customised and intricate designs can be created. Objects may be made in a wide range of materials including plastics and metals. 3D printing has become more common as the cost of printers has fallen and their ease of use has improved. These devices open up options for design and creativity previously only available to those with a workshop or factory at their disposal.

3D printing is an umbrella term encompassing several different technologies (Pham & Gault, 1998). The printer purchased for the RSL uses the technique of Fused Deposition Modelling (FDM). For this method to work a 3D model is first 'sliced' in the computer. The slicing process generates a sequence of instructions which tell the printer exactly how to deposit layers of material such that the virtual 3D model is replicated physically. At its simplest the printer itself consists of a horizontal build plate which can be automatically raised and lowered (z-axis movement). A print head, attached to a system of gears, is suspended above the build plate. These gears allow the print head to move forwards, backwards, left and right over the build plate (x- and y-axis movement). The print head is heated to a temperature in excess of 200^{o}C and a fine filament of plastic is drawn into the top of the print head and melted. The print head is moved over the board in the x- and y-axes while a thin line of melted plastic is extruded onto the board in the shape of the first layer of the object. The plastic sets almost instantly. The build plate is then moved down a fraction of a millimetre. A second layer of plastic is applied to the first and the heat of the upper layer of plastic bonds the layers together. This process repeats tens or hundreds of times in order to produce a finished object.

Libraries and 3D Printing

A number of academic libraries provide 3D printing services (Massis, 2013). Examination of these services raised several important questions to consider before implementing a service at the RSL.

1. What level of service should the RSL provide?
2. What type of equipment should be purchased?
3. How should the service be financed?
4. What are the implications for library policies?
5. Was there evidence that 3D printing services had been successful in other libraries?
6. Would a library 3D printing service duplicate existing services already available at Oxford University?

What level of service should the RSL provide?

Libraries have offered differing levels of 3D Printing service which appear to fit into three categories.

1. A self-service approach where readers can print off their own models with relatively little staff intervention beyond routine maintenance (e.g., the University of the West of England Library (University of the West of England, 2013)).
2. A service mediated by librarians who receive jobs to print, check and process the models for printing and manage the printing process (e.g., the Lovejoy Library, Southern Illinois University and Dalhousie University Library (Groenendyk, 2013; Groenendyk & Gallant, 2013; Pryor, 2014)).
3. A service that is part of a wider Makerspace or design studio. The library provides equipment and design software to users and actively trains them on how to use the resources. Additional equipment such as laser cutters, electronics kits, etc. may be provided in addition to 3D printers (e.g., University of Alabama Libraries and DeLaMare Science and Engineering Library, University of Nevada (Conway, 2014; Scalfani, Sahib, & Sandy, 2013)).

The first option on the list above was considered too passive; it would not meet the strategic goal of engaging with researchers nor would it offer sufficient support to users wishing to try the printer. The last option on the list was also infeasible because the resources and suitable accommodation for a Makerspace within the RSL were unavailable. The RSL therefore opted for a version of the second option in which staff would run the printer as a mediated service.

What type of equipment should be purchased?
A wide range of 3D printers are available (Hoy, 2013, pp. 97–98). One brand used by libraries and found to offer reliable, easy operation has been the Makerbot Replicator line (e.g. (Groenendyk & Gallant, 2013; Pryor, 2014; Thompson, 2014)). These FDM printers use a biodegradable, non-toxic thermoplastic called PLA (Polylactic acid) (Pettis, France, & Shergill, 2012). RSL staff visited a company in London specialising in 3D printing and robotics to discuss options for 3D printers with a technician (RoboSavvy Ltd, n.d.). This visit satisfied the librarians involved that the Makerbot Replicator 2, Makerbot digitizer scanner and Sense scanner would be suitable and affordable devices for the RSL.

How should the service be financed?
Each print job consumes plastic and results in wear and tear on the printer's mechanism. The cost of a spool of PLA is around £35 per kg. This is typically sufficient to produce a large number of models. It was essential to keep the cost of the RSL service as low as possible to encourage users to try the new service, and a simple way to charge for printing was by making costs proportional to printing time. The RSL decided to charge £2 for the first hour of printing and £1 for each additional hour. These charges cover the cost of materials and provide a surcharge to put towards replacement parts for the printer.

What are the implications for library policies?
Implications of 3D printing on library policies were also considered, in particular health and safety and copyright. Health and safety risks were minimised by selecting a printer that uses a non-toxic plastic and by opting for a staff-mediated service so that library users would not have direct contact with the equipment. Copyright issues regarding 3D printing are a complicated legal area (Grimmelmann, 2014). It was important to have a printing policy which prohibited obvious breaches of copyright. A policy was prepared for 3D printing at the RSL specifically prohibiting the copying of artistic works (Schultz & Bridle, 2015a). This was another area where operating a mediated service proved useful; on several occasions staff intercepted models that were likely to infringe copyright.

Was there evidence that 3D printing services had been successful in other libraries?
All of the examples of 3D printing services so far found in the literature have been well received by patrons to varying degrees. Thompson, for example, reports an enthusiastic student response, but with usage of the printer mainly confined to producing knick-knacks and novelty items at first (2014). Scalfoni and Sahib trained 50 patrons to use the 3D printer in the first two months of offering workshops at the University of Alabama (2012). They reported that responses to the workshops were 'overwhelmingly positive' [*ibid.*]. Pryor noted that the 3D printing service at the Lovejoy library received relatively few print requests, but those students who did use the printer were excited and enthusiastic (2014). Pryor suggests that low usage could be attributed to the difficulty of designing CAD models from scratch [*ibid.* pp. 7-8] Pryor concluded that better promotion of online model repositories such as Thingiverse could address this issue and ensure that it does not create an entry barrier for using the service. This lesson was taken on board at the RSL and design repositories were highlighted in the online 3D printing and scanning LibGuide and at 3D printing events in the library. The RSL has also provided two 3D scanners which give uses other easier options for generating models.

Would a library 3D printing service duplicate existing services already available at Oxford University?
An examination of 3D printing services available at the University was undertaken to ensure that the library would not duplicate an existing facility. At Oxford University, the Department of Physics offers 3D printing services through its Mechanical Design Office (University of Oxford Department of Physics, 2012). The Office provides support for CAD design and high quality 3D printing. However, the service is designed for academic use and is expensive. A number of laboratories and departments also have 3D printers. For example, the Department of

Engineering Science has a 3D printing service for its members, and the 3D printer is used on some teaching courses. Printers in these situations are generally restricted to members of a lab group or particular department. Oxford IT Services offer courses in CAD design using the SketchUp and Blender software applications, but do not provide a 3D printer.

After an examination of the literature to gain answers to the questions above, it was decided that offering a 3D printing service at the RSL was both practically possible and would provide an exciting and useful service for patrons. The library's ability to provide the service at a very low cost to any University member and a willingness to accept 'non-academic' items for printing meant that the RSL could fill a niche not served by existing 3D printing options at the University.

The Bodleian Libraries have an overall three year strategic plan for 2013-16, and it is important that projects undertaken fit within the framework of this plan so that constituent libraries are working towards the same goals (The Bodleian Libraries, 2013). The Bodleian Libraries also has an Implementation Plan that details what the library's strategic goals are and how they are to be achieved. The 3D printing project comes within section 8 of the plan under the heading 'Digital Initiatives', being defined as to 'Develop digital technologies that benefit research, teaching and learning' (The Bodleian Libraries, 2014, p. 3). The project is an excellent fit for this particular objective as it provides access to new technology and, as will be seen from the examples of how the printer has been used, has certainly provided opportunities for research, teaching and learning.

Developing a printing service for the RSL

The first step in putting the service into practice was to gain funding for the purchase of a Makerbot Replicator 2, a Makerbot Digitizer and Sense scanner, plus supplies of PLA plastic to get the service started. Funding of £4000 was obtained by successful application to the Helen Roll Charity. Once the equipment was acquired, subsequent steps were as follows:

1. Learn how to use the equipment
2. Create procedures and policy for the printing service
3. Train staff volunteers to help run the service
4. Advertise and promote the service to users

Two Subject Librarians at the RSL led the 3D printing project and spent several months learning how to operate the printer hardware and software. An instruction manual for staff detailing the main functions of the printer and scanners was created and a LibGuide for patrons was built to explain and promote the service.

A policy document informing library users of the limitations of the service was written. The policy lays out the grounds the library may have for rejecting print jobs if they contravene copyright or other Intellectual Property laws. Additionally the policy rules out the printing of weapons or offensive items. The RSL policy was based on that developed at several other libraries, details of these can be found on the LibGuide (Schultz & Bridle, 2015a).

The project leaders held several presentation events for RSL staff in which the 3D printer and scanners were demonstrated. Interested staff were invited to volunteer for further hands on training to equip them with skills for managing print jobs. Getting other members of RSL staff involved with the project was essential because somebody is required to stay with the printer while it is running in order to monitor print outs and rectify problems as they arise. Staff are required to administer the queue of print jobs and ensure payments are collected and readers are informed when jobs can be collected.

Several routes were followed to promote the service. Firstly, remaining money from the original grant was used to design and print professional quality flyers and posters. Secondly, Subject Librarians were encouraged to circulate information about the service to their respective departments. Thirdly, social media tools such as Twitter, Facebook and the RSL library blog were exploited to spread the word. Fourthly, a display case containing examples of 3D prints and captions explaining the 3D printing process was put on public display in the entrance hall of the RSL to attract the curiosity of readers and demonstrate the capabilities of 3D printing (fig. 1). Finally, in order to launch the service, a week of promotional events was organised at the RSL. Events consisted of demonstrations of the 3D printer in public areas of the library, 'Bring a Design' sessions at which readers were able to bring a model to print and/or have themselves scanned using the Sense scanner. During these events, members of the 3D printing team were on-hand to answer questions about 3D Printing and Scanning. An afternoon of talks at the

library was also arranged. These talks were given by students and staff from Oxford and Oxford Brookes Universities who already used 3D printing in their teaching or research (details of the talks may be found on the LibGuide (Schultz & Bridle, 2015b)). These talks illustrated the power and utility of 3D printing in an academic setting and emphasised that the technology is far from being a gimmick.

Figure 1. A display of 3D printed objects at the RSL aims to educate library users about 3D printing and demonstrate its versatility.

Running the Service

To use the RSL 3D printing service a reader approaches the library by e-mail (a dedicated e-mail address for the service is available) or in person with a model which they want to print or object which they wish to scan. Objects are submitted in the STL (stereo lithography) file format, which is a standard format for 3D models. A member of the 3D printing team opens the file using the Makerbot Desktop application and runs several basic checks. These include ensuring the model is scaled correctly and that it does not contravene policies on copyright. The member of staff decides if the model requires additional supporting structures to prevent collapse during printing and adjusts the software settings accordingly. When the member of staff and the reader are satisfied, the Makerbot software is used to create a printing file and simultaneously estimate the printing time. The reader is charged according to the printing time for the model. Payment is taken up-front in cash before printing, and the reader is issued with a printing ticket. Full details of the print job are inputted into a spreadsheet that is used to track the progress of the print job and record the readers contact details. The print job is assigned to a member of the 3D printing team, who is responsible for operating the printer to print the reader's object and subsequently informing the reader by e-mail that the job is finished. The majority of print jobs are completed within seven days.

Readers may also book one-on-one consultations with a member of RSL staff to discuss a particular printing project. These consultations are also used to help people scan objects using one or both of the available scanners. The library does not charge for the use of the scanners.

Reception of the 3D Printing Service

The 3D printing service has been well received and extremely popular. The launch events attracted almost 100 people, and there were many questions and great curiosity about the printer. The RSL now runs at least two 'Bring a design' events each term and these attract around 20 - 30 people. Between starting the service in December 2014 and the beginning of May 2015 almost 90 orders for models from readers have been printed. The appeal of the printer has been wide ranging with individuals coming from departments including Engineering, Chemistry, Zoology, Biochemistry, Computer Science, Mathematics, Archaeology, Experimental Psychology and Statistics. Models have varied between 'fun' items, such as Christmas decorations, to models and prototypes for academic applications and research. One particularly popular item is the production of head or full body scans of readers. These are created by using the Sense 3D scanner to scan a reader and then print a scaled down model. This has allowed readers to engage with the technology in an entertaining way. Academic applications have included producing mathematical models from formulas generated in Mathematica, using data from a recent paper in PLOS One to print a fragment of a dinosaur's cranium (Farke, Maxwell, Cifelli, & Wedel, 2014), producing 3D models of molecules to use as teaching aids and printing prototype designs for an undergraduate engineering project. Further case studies demonstrate the impact of the 3D printing service on academic projects at the University.

Case Study 1. An MRI scanner toy

A member of the Cohen Kadosh lab in the Experimental Psychology Department approached the RSL 3D Printing Service with a request to print a toy version of an MRI scanner. This lab is investigating brain development and mathematical achievement in children and adolescents. Part of the research involves conducting brain scans using an MRI scanner. The scanner can be an intimidating environment as the experience can be claustrophobic, and the machine is extremely noisy when operating. It is important both for the results of the brain scanning and the ethical acceptability of the research that children do not become distressed during the scanning procedure. Staff at the RSL were able to work with the researchers to print a scaled toy model of the MRI scanner that children could play with and, by using small Lego characters, be shown how the machine worked (fig. 2). This reduced the children's anxiety about the scanning.

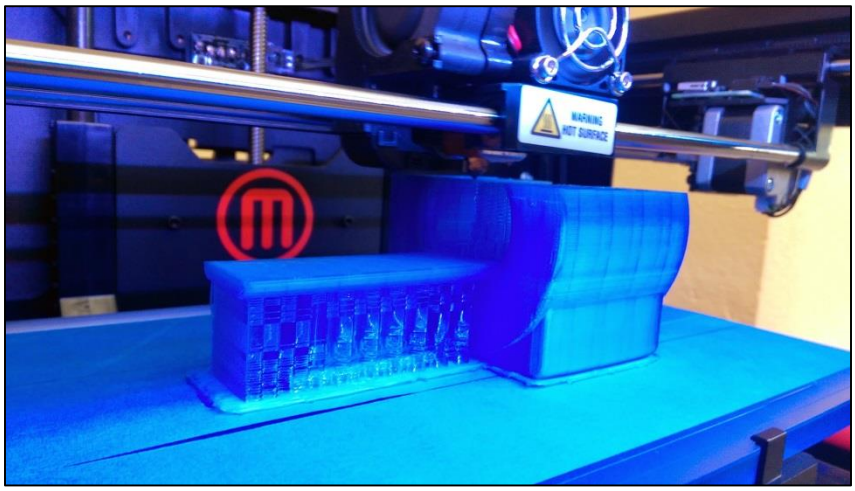

Figure 2. The MRI Scanner toy being printed on the RSL Makerbot Replicator 2.

Case Study 2. Bronchi Model

Members of the Ritchie Group in Physical Chemistry are developing a new probe to monitor levels of carbon dioxide inside human lungs. The probe is to be attached to the end of a bronchoscope, a flexible instrument that can be guided down the airways deep inside the lungs. The researchers required a model set of bronchial passages that they could use to simulate guiding the probe through. The researchers had identified a model design freely available online, which they were able to adapt to meet their requirements. The 3D printing service at the RSL was able to help create a prototype model, and then a larger version printed in several separate pieces (fig. 3). The model proved to be challenging because of the intricate shape of the printed parts and the fact that the interior of the model had to be hollow and free of supporting structures.

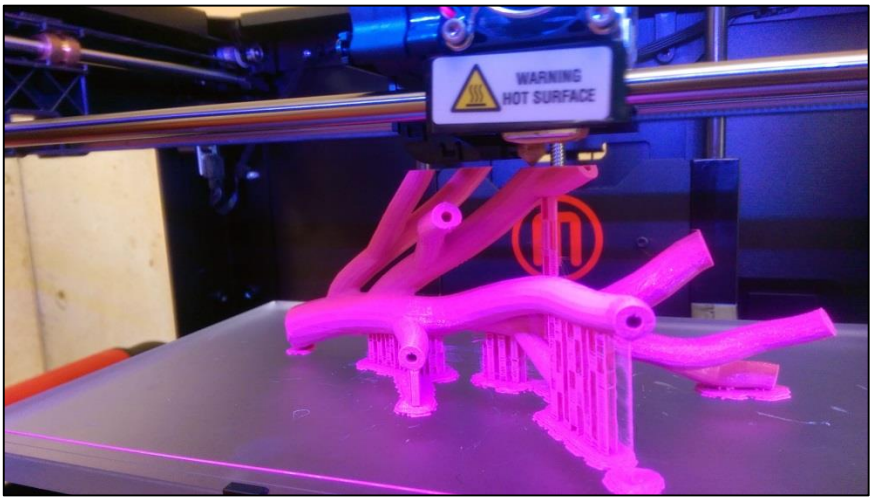

Figure 3. One section of the Bronchi model printing.

Through these case studies and similar projects, the library has documented tangible instances of where a library service has had a direct and positive impact on research, something that is often difficult to demonstrate. From the library's perspective, the 3D printing service successfully fulfils the strategic goal of finding new ways to engage with researchers.

Challenges and Difficulties

Problems encountered with 3D printing have mainly fallen into four categories:

1. Print jobs too large
2. Prints failing due to the technical limitations of the Makerbot, for example, particularly small model parts do not print sufficiently accurately for some applications
3. Jobs rejected due to copyright infringement
4. Users unable to provide a working model file to print from

In most cases it has been possible to assist users by providing constructive advice when problems arise. For example, models may be scaled down if too large. Alternative legal models to print, in the case of copyright problems, are suggested. Users are also directed towards other sources for 3D printing in Oxford or available commercially when the library service is not suitable. Adjustments in policy have been made in response to problems. For example, after receiving a number of early requests for large prints which could not be practically accommodated, the policy was changed to limit any one print job to a maximum of five hours.

Other challenges have arisen from practical issues of staffing and maintaining the machine. Although routine maintenance is simple and minimal, printer breakdowns can require considerable staff time to diagnose and repair faults. The lack of a second printer has meant that faults must be dealt with urgently so that the service can continue.

Future Developments

The 3D printing service is an ongoing project at the RSL and the library receives a steady stream of requests for printing and scanning. In light of the success of the project, funding has been made available to purchase a second printer. This will help address some of the difficulties with printer breakdowns outlined above. Over the next year the 3D printing team plans to work closely with academic departments to offer support for taught courses wishing to utilize 3D printing.

New services and library strategy

At the beginning of this paper it was noted that innovative library strategy, when it comes to offering new services, can be reactive, where the library has to develop a new service in response to external changes, such as funders' open access mandates. Alternatively they may be proactive by seeking to provide new services which fall outside 'traditional' library offerings. Adopting a proactive strategy has meant that the RSL has earned new opportunities to engage with researchers and maintain the relevancy of the library in times of changing user needs and expectations.

The lesson to draw from the RSL experience is not that all libraries should buy 3D printers, but rather that libraries should incorporate the proactive creation of new services into their strategic planning. Innovation does not have to be technological; it could involve reorganising library spaces to better suit readers needs or partnering the library with other organisations. For example, the RSL has recently begun working with ISIS Innovation, Oxford University's technology transfer company, to provide consultation points for researchers within the library to discuss topics around the commercialisation of research outputs.

Although developing new services may involve risk and investment, the rewards can be significant. Risks can be minimised by looking carefully at what has worked in other libraries, conducting research into new trends and technologies and, where necessary, looking for sources of external funding to purchase new equipment or materials.

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References Cited

Conway, A. (2014, July 17). University recognized as one of the most interesting makerspaces in America. Retrieved 7 May 2015, from http://www.unr.edu/nevada-today/news/2014/makerspace

Farke, A. A., Maxwell, W. D., Cifelli, R. L., & Wedel, M. J. (2014). A Ceratopsian Dinosaur from the Lower Cretaceous of Western North America, and the Biogeography of Neoceratopsia. *PLoS ONE*, *9*(12), e112055. http://doi.org/10.1371/journal.pone.0112055

Grimmelmann, J. (2014). Indistinguishable from Magic: A Wizard's Guide to Copyright and 3D Printing. *Washington and Lee Law Review*, *71*(1), 683–698.

Groenendyk, M. (2013). *A Further Investigation into 3D Printing and 3D scanning at the Dalhousie University Libraries: A Year Long Case Study*. Dalhousie University.

Groenendyk, M., & Gallant, R. (2013). 3D printing and scanning at the Dalhousie University Libraries: a pilot project. *Library Hi Tech*, *31*(1), 34–41. http://doi.org/http://dx.doi.org/10.1108/07378831311303912

Hoy, M. B. (2013). 3D Printing: Making Things at the Library. *Medical Reference Services Quarterly*, *32*(1), 93–99. http://doi.org/http://dx.doi.org/10.1080/02763869.2013.749139

Lipson, H., & Kurman, M. (2013). *Fabricated: the new world of 3D printing*. Indianapolis, Indiana: John Wiley & Sons.

MakerBot Thingiverse. (n.d.). Retrieved 13 May 2015, from http://www.thingiverse.com/

Massis, B. E. (2013). 3D printing and the library. *New Library World*, *114*(7-8), 351–354. http://doi.org/http://dx.doi.org/10.1108/NLW-03-2013-0030

Pettis, B., France, A. K., & Shergill, J. (2012). *Getting started with MakerBot*. Sebastopol, Calif: O'Reilly.

Pham, D. T., & Gault, R. S. (1998). A comparison of rapid prototyping technologies. *International Journal of Machine Tools and Manufacture*, *38*(10–11), 1257–1287. http://doi.org/10.1016/S0890-6955(97)00137-5

Prince, J. D. (2014). 3D Printing: An Industrial Revolution. *Journal of Electronic Resources in Medical Libraries*, *11*(1), 39–45. http://doi.org/10.1080/15424065.2014.877247

Pryor, S. (2014). Implementing a 3D Printing Service in an Academic Library. *Journal of Library Administration*, *54*(1), 1–10. http://doi.org/http://dx.doi.org/10.1080/01930826.2014.893110

RoboSavvy Ltd. (n.d.). RoboSavvy. Retrieved 13 May 2015, from http://robosavvy.com/web/

Scalfani, V. F., & Sahib, J. (2012). A Model for Managing 3D Printing Services in Academic Libraries. *Issues in Science & Technology Librarianship*, (72). Retrieved from http://search.proquest.com/lisa/docview/1504415310/F5B90807677D40FCPQ/3?accountid=13042

Scalfani, V. F., Sahib, J., & Sandy, J. (2013). *3D Printing at The University of Alabama Libraries*. University of Alabama. Retrieved from https://library.stanford.edu/sites/default/files/Univ%20of%20Alabama.pdf

Schultz, K., & Bridle, O. (2015a, April 22). 3D Printing and Scanning. Policy. [LibGuide]. Retrieved 13 May 2015, from http://ox.libguides.com/content.php?pid=616017&sid=5092980

Schultz, K., & Bridle, O. (2015b, April 22). 3D Printing and Scanning. Services & Events. [LibGuide]. Retrieved 13 May 2015, from http://ox.libguides.com/3dprintingscanningevents

The Bodleian Libraries. (2013, October). Strategic Plan : Mission Statement. Bodleian Library, Oxford University. Retrieved from http://www.bodleian.ox.ac.uk/__data/assets/pdf_file/0008/156788/Strategic-Plan-2013-2016.pdf

The Bodleian Libraries. (2014, February). Bodleian Libraries Implementation Plan 2013-2016. Bodleian Library, Oxford University. Retrieved from http://www.bodleian.ox.ac.uk/__data/assets/pdf_file/0019/164170/PUBLICImplementation-Plan.pdf

Thompson, E. (2014). Makerbot Replicator 2: 3D Printing Tips From an Early Adopter. *Computers in Libraries*, *34*(6), 4–8.

University of Oxford Department of Physics. (2012, February 16). Mechanical Design office. Retrieved 13 May 2015, from https://www2.physics.ox.ac.uk/enterprise/services-and-specialist-equipment/mechanical-design-office

University of the West of England. (2013, January 21). UWE Bristol offers 3D printing to all students. Retrieved 7 May 2015, from http://info.uwe.ac.uk/news/UWENews/news.aspx?id=2442

Warnier, C., Verbruggen, D., Ehmann, S., & Klanten, R. (Eds.). (2014). *Printing things : visions and essentials for 3D printing*. Berlin: Gestalten.