Chapter

ACADEMIC LIBRARIES AND TECHNOLOGY: AN ENVIRONMENTAL SCAN TOWARDS FUTURE POSSIBILITIES

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ABSTRACT

This research conducts an environmental scan of current best practices in academic library technology to reflect on future landscapes. The work takes the premise that by projecting out from current leading-edge technology realities, it is possible to better plan for the future. Academic Library learning commons, 3D printing labs, makerspaces, online data research repositories and information literacy are overviewed to reflect on future academic library vistas. Academic needs and library areas are surveyed through themes of: collaborative, networked and emergent technologies, digital and information literacy, open source frameworks, online collections, the scholarly record and artificial intelligence. This research is meant to provoke and spark discussion, surveying present best practice thematic areas through various current sources and the author's own pragmatic work and research in academic libraries and leading-edge information technologies.

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INTRODUCTION

Academic libraries are changing at a whirlwind pace in our 21st century. Books are being carted off to repositories, technology-rich learning commons are expanding to take over libraries and the growth of the digital library has been a paradigm shift to say the least. Within these large sea changes, it is challenging to keep up with the blistering pace of academic library technology transformation and wider societal technology changes. No one who has recently worked, or is working, in academic libraries would say they are a boring or slow-paced place. In fact, the exact opposite is true. This chapter takes a circumspect view of academic library technology futures, reflecting on wider contexts from our present day. It speculates on long range academic library necessities extrapolating from current technological trends to consider various scenarios of what is occurring in academic libraries and what this implies for the future. In this way, this work presents an environmental scan of the leading edge, but also, strong foundations of academic library technological directions for further discussion and debate. The purpose is to help leaders and future leaders in academic libraries with implementing technology and planning. The chapter surveys the current landscape of academic library technologies, relying both on communities of practice operating in academic libraries circa 2018, current library technology-related published literature and also, the author's own work over the past twenty years (See Bibliography).

What is on the long term horizon for academic libraries? Is it necromancy to even try and guess at predictions regarding technology

trajectories, academic libraries and the university campus? How can library leaders strategize along more visionary lines? This research provides more focused thought on library technology, strategy, services and stewardship. It contextualizes various big picture themes, among them: networked technology, digital literacy, collaborative technologies, open source frameworks, online collections, the scholarly record, emergent technologies and artificial intelligence. Through this environmental scan, guideposts and building blocks emerge toward the future. Hopefully, these grounded speculations will carry forward towards better planning and stewardship of our collective future.

NETWORKED TECHNOLOGY AND ACADEMIC LIBRARIES: THE BIG PICTURE

To begin with a conjecture, networked technology has enabled cross-institutional collaboration like never before. It is more likely that a faculty member will be collaborating with a colleague half way across the world in Tokyo, than in the office next door. Today's global environment and technologies easily allow academics to collaborate across international borders and work towards enabling research with the best and the brightest in their field of specialization on global levels. Academic libraries are also part of this new global village of collaboration, particularly through digital collections, archives, consortia and resources. The scholarly record is evolving, too, and has expanded exponentially from print-based journals and monographs to a networked environment on the open web, in databases and behind paywalls. The range of digital media, online applications and tools scholars are using is staggering. Scholarly research products have also exponentially expanded from traditional pen and paper articles and books. This ranges from online research data sets, to custom-made programs, to specialized scholarly information social media networks, to data visualization applications, to a whole series of intermediary work artifacts (preliminary to serial or monograph

publication) that are now easily shared. Academic libraries have also evolved to access, organize, enable and preserve these new research artifacts and environments generated. Current scholarly web-based exchanges and forums, via social media, provide fascinating views into the evolution of the scholarly record, but also highlight the profound challenges for libraries, digital archivists and archiving. As different aspects of the scholarly communication cycle emerge in the 21century, the role of library and librarian as curator, organizer and steward of this wealth of new information and knowledge is also dynamically evolving (Figure 1).

The term 'digital scholarship' has also increasingly come into vogue in the last few years. The larger idea is a marrying of traditional disciplinary enquiry methods to new technological possibilities for academic libraries ranging from digital archives and digital libraries to multimedia exhibitions, learning commons, visualization walls and big data representation. The best academic libraries today juggle and synthesize all of the above noted technologies and technology infrastructures in a constant dance with changing societal norms. With these new possible permutations of technologies and digital asset management systems (DAMS), areas of digital preservation become increasingly important in the academic library's historical stewardship role. The larger 'lifecycle' of the scholarly research enterprise allows for libraries to take precedence in traditional roles of organizing, preserving, aggregating and making this new corpus of information and knowledge accessible. In the digital age too, academic libraries are necessarily taking up new areas of 'digital forensics' to retrieve the digital scholarly record where quick obsolescence of file formats and media is a hallmark of the times (Wolverton, 2016).

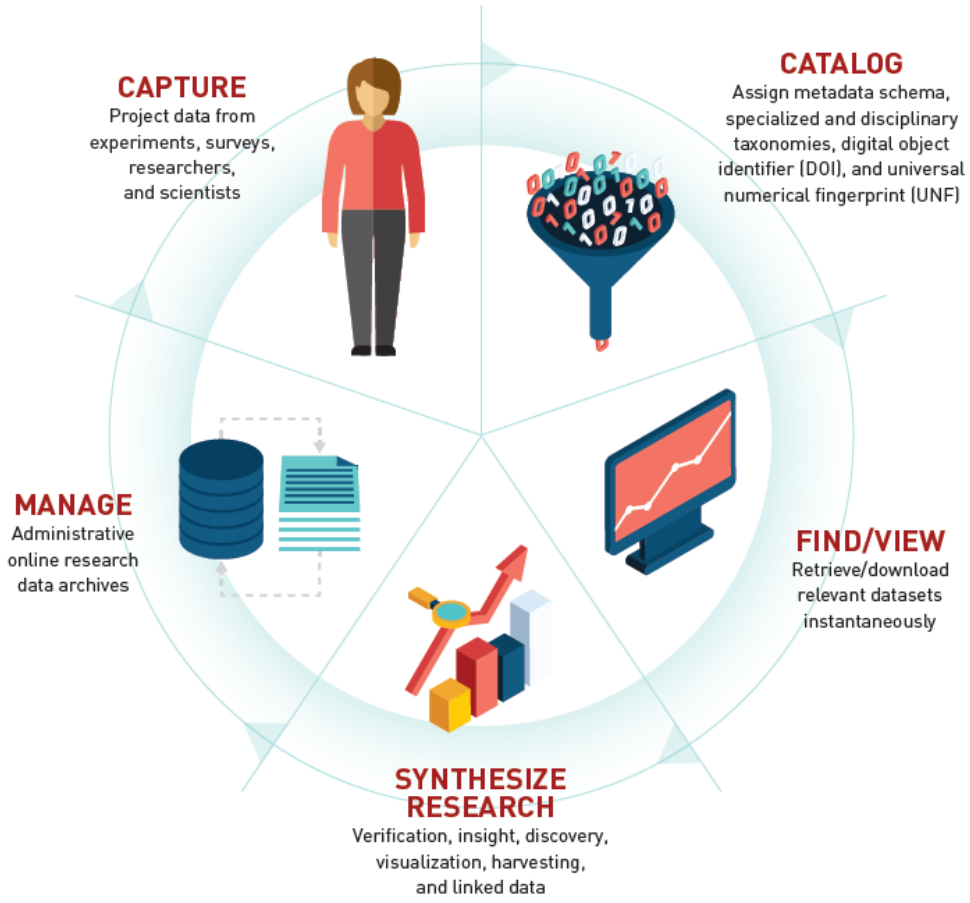

Figure 1. The Scholarly Online Data Repository Research Cycle: Capture, Catalog, Find, Synthesize, Manage. Image from Uzwyshyn, 2016b.

STUDENT AND FACULTY AS PRODUCER

The student and faculty of today have become producers of data, information, media and knowledge. Ours is a digital-production-oriented society and the university campus and library is no exception to the rule. Education has taken on interactive, productive and creative modalities. Academic libraries are also now being asked to assist with this new interactive ethos needed for this global community to produce these largely

digital scholarly artifacts. This is the evolution of the library's natural role as disseminator of knowledge and facilitator of new modalities of digital literacy.

To take a single example, many academic libraries have taken the 3D printer and scanner lab paradigm up, opening possibilities (Uzwyshyn, 2015). The backroom engineering-oriented lab has been reconfigured towards a wider grouping of Social Sciences, Humanities and other disciplines ranging from Medicine to Forensic Anthropology (Figure 2). Everything, from printing human hearts to architectural designs, is being printed to facilitate and enable learning and research. We are in a new Gutenberg phase with 3D printing. What will these new technological 'makerspace' possibilities and marriage with the traditional academic library engender towards the university research environment? The academic library, too, is the perfect place for these makerspaces and Fab Labs (Fabrication Labs), as the multitude of disparate disciplines in a university can congregate within the third space of the academic library to produce yet unthought-of artifacts. Separate academics and disciplines can find common ground in the third interdisciplinary space of the library through technology enabling congruencies and synergies.

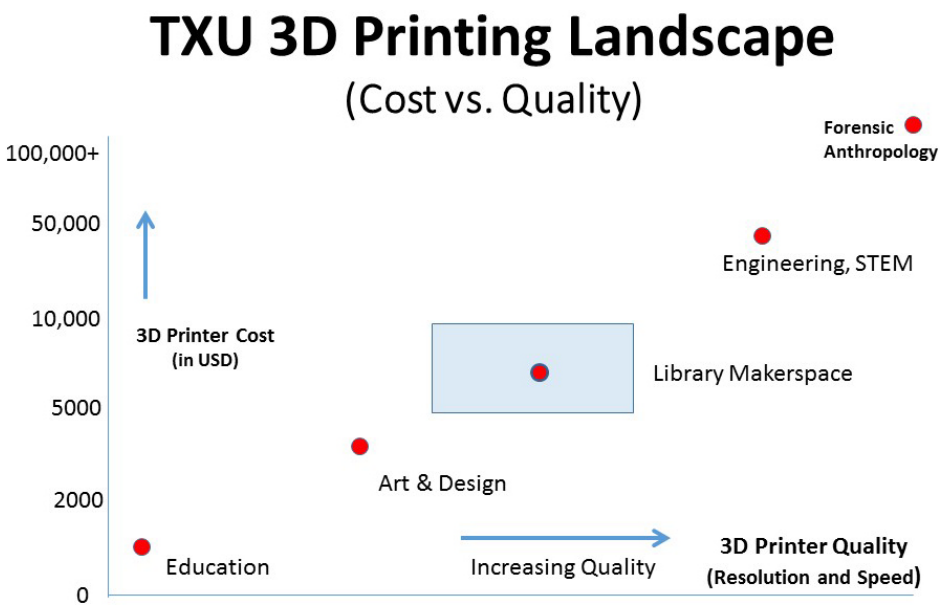

Figure 2. The Academic 3D Printing Landscape. Cost of 3D Printers versus Print Quality and Different Disciplinary Needs. Graph from Uzwyshyn, 2015.

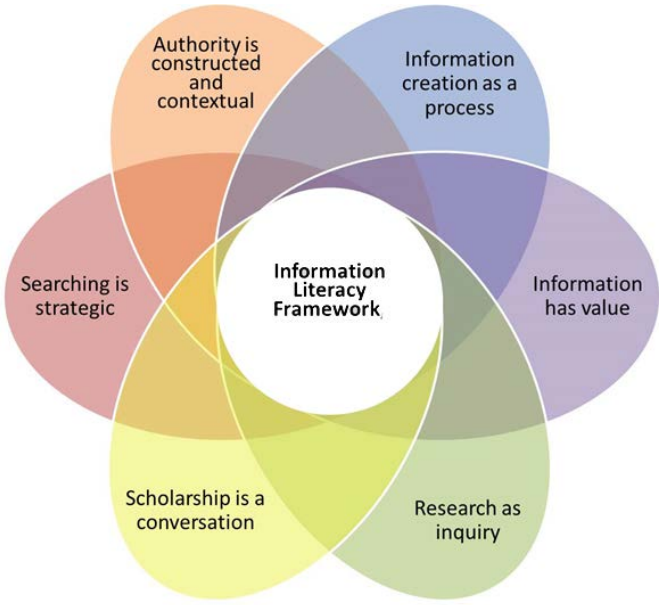

Figure 3. The ACRL Framework for Information Literacy and the Six Major Frames.

INFORMATION AND DIGITAL LITERACY

Another aspect of academic libraries that has come to the forefront with the advent of technology is the necessity of digital literacy with regards to the profusion of information available through the internet and education needed as to 'veracity' and 'reliability' of information. Here 'mindful media consumption' and the ability to discriminate between 'real' and 'fake' news becomes increasingly important in the maintenance of a democratic society and an educated populace (ACRL, 2017). With the double-edged sword of the wealth of information that the internet has enabled, the possibility of an individual becoming isolated in a narrow horizon of retrograde ideology becomes increasingly problematic. Many people now have trouble distinguishing between reliable and unreliable sources of information, unable to discriminate between 'fake news' and 'the real.' In this environment, socially divisive possibilities and movements can become increasingly prevalent. Here, academic libraries have the larger duty to educate with regards to information literacy as real world skills for a changing global workforce and democratic populace. Currently, the gold standard for this type of digital literacy is the American Council of Research Libraries (ACRL), 'Framework for Information Literacy for Higher Education' (Figure 3), which presents an excellent set of higher principals to follow (ACRL, 2017). The needs for both faculty and student information literacy will continue to evolve as the internet changes. Fake news is currently associated with advertising, larger ideological agendas and mass consumption. The gullibility of a larger university and college-educated populace. unable to discriminate, is particular troubling and academic libraries need to be working in close concert with faculty, academic departments and schools (CARLI, 2017).

COLLABORATION AS METAPHOR IN PHYSICAL AND DIGITAL LIBRARY ENVIRONMENTS

Collaboration in academic libraries is taking place on many levels. On physical levels, learning spaces are being redesigned for collaborative learning, especially with student populations (Uzwyshyn, 2016a). Architects, in dialogue with librarians, IT and faculty, are reconceptualizing traditional 19th century Cartesian desk, stack and table environments to more creative ones, synthesizing physical, social and digital spaces through technology and possibilities that the digital space allows (Uzwyshyn, 2017). In seed form, but continuing to evolve, the powerful computers all students and faculty now carry in their pockets (the mobile device) is being married to the physical library through a range of functions and new Internet of Things (IoT) type possibilities (Chang, 2016). This paradigm shift ranges from being able to print from one's phone, to library tours, to more complex social network tasks, such as finding groups of similar students who are studying the same topics for research groups/classes collocated in the similar physical space. Data analytics also has a big role to play with this new Internet of Things, mobile and learning commons collaborative possibilities, principally to analyze how students and faculty are actually using these new digital hybrid spaces, for what purposes and to what ends (Chang 2016). New partnerships with industry are also possibilities with IoT for future academic library innovation where wider societal IoT paradigms abound.

Increasingly, academic libraries are also hiring a wider range of academics and anthropologists who study 'information ecologies' and student/faculty group behavior and interactions in these new digital hybrid learning spaces (Schwartz, 2012). What is the scholarly community actually doing in these spaces? How are they interacting with and using them? What do they wish to do and what is not yet possible? How are user communities reconfiguring, rearticulating and remixing these physical technology-rich environments to enable research, learning and library possibilities? An ever wider range of academics (sociologists,

ethnographers, linguists, psychologists) are now being employed by academic libraries to focus their more traditionally oriented research study methodologies towards the library learning space and these new information environments, ecosystems and ethnographic cultures. In turn, these new studies and digitally captured metrics combine and evolve by feedback, evaluation and assessment to create new library spaces. The hot, new, dark continent with plenty of virgin territory to explore, is no longer Africa, the new world or outer space, but digital and physical information technology landscapes and ecologies of learning commons and virtual library environments (Nardi and O'Day, 2000). The larger ideas here are guided by 'design thinking' and iterative agile project management methodologies (Figure 4). For the design thinking, this means an application of these wider context design principals to accommodate human needs within these new technologically feasible possibilities for research and learning. For Agile project management iterative methodologies, these are oriented to the changing environment of the learning commons, and building and rebuilding this quickly changing

techno-hybrid environment (Uzwyshyn, 2012a). Through gathered data analytics and these new anthropologists' field notes, agile new library learning environments may be generated organically to create these larger new hybrid 'information' ecosystems.

Figure 4. The Agile Project Management Iterative Design Cycle.

Figure 5. The virtual online library is central to online and hybrid university models.

New learning space developments are also being shared online with leading-edge models being submitted to other online databases such as the Flexible Learning Environments Exchange (Flexspace, 2017). These online tools aggregate examples nationally and internationally of leading-edge library learning spaces for others to follow and synthesize and remix towards their own needs. Many traditional academic libraries are being reconfigured completely from their print/serial traditional 20th century warehouse roles. In this newer trend, at times millions of books are shipped off in tandem with multi-decade serial print runs for offsite repository storage and retrieval. These vacated library spaces open large possibilities for makerspaces and learning commons.

The academic library web site for most research academics has become the actual library (Figure 5). Materials acquisitions budgets are literally spending 80%, or more, of multi-million dollar acquisitions budgets on disciplinary databases and other electronic resources. The library Digital, Metadata and Acquisitions Departments become coordinators, organizers and aggregators of various external data pipes with internal information systems. In these cases, the online librarian and online library become central to utilizing this virtual library for upper level undergraduates, graduate students and research faculty. In completely 'online university environments,' this model is stepped up so the online librarian works closely with faculty members and students through various virtual communications technologies. When the university becomes a virtual environment, the online library, learning management system and the online social network, become central to the learning process (Uzwyshyn, Smith, Coulter et al., 2013).

OPEN SOURCE TECHNOLOGIES

On software levels, many academic library areas work very closely with University IT, vendors and other libraries in developing technology for community needs. For the many disaggregated systems needed for academic libraries, open source technology is utilized or created.

Typically, many of these recognized software projects have become multi-institutional, longer term efforts. These infrastructures take the combined efforts and expertise of many academic institutions working on these projects together to advance these global-level applications (i.e., Fedora, Hydra, Vireo, Dataverse) for the larger academic library community. Grant funding from US and international agencies (i.e., IMLS, NSF) are increasingly being given for these collaborative institutional efforts across multi-institutions to combine programming power and human resource expertise to create new tools for the academic library community (IMLS, 2017). This eases the burden on single institutions and standardizes the playing field to create larger agreed-upon information ecosystems. Collections are also becoming more collaborative with interlibrary e-loan, lending and borrowing the norm. Huge digital repositories (Hathi Trust) now contain thousands of Exabytes of digital files for interlibrary loan (2017). Increasingly, institutions within a consortia or geographic area are designated to keep single copies of print monographs and serials, so that a consortium does not have to keep multiple print copies of obscure and rarely consulted runs of serial archives locally. This consortial aggregation trend is likely to continue. Digital collections are also increasingly shared through metadata interoperability and harvesting of remote digital collections into a catalog and/or catalog of catalogs.

ONLINE COLLECTIONS

Online collections of all media types are also becoming aggregated and remixed on state, national and international levels. For example, the Online Texas Research Data Repository (Figure 6) aggregates 22 Texas universities' online research data to create a large online data repository to facilitate further collaboration, but also to centralize some of the individual university administrative programmatic duties towards longer term strategies in dealing with the online research data deluge (Texas Data

Repository, 2017). The scholarly data research lifecycle, from collection, to analysis, to data visualization and long term preservation and storage, also becomes key in this model (Uzwyshyn, 2016b, See also figure 1). Staff training for research data management also becomes paramount. Librarians are quickly becoming, by necessity, data scientists, data librarians and data curators. The academic library provides the role of access, support and data management, also training the university's disciplinary faculty and students in principles and best practices of data literacy (Texas Digital Library, 2017). This ranges from expertise towards where the relevant data in a particular subject area is, to enabling students and faculty to cite, manage and store their own academic research data for future re-use, access and data citation. Metadata and evolving metadata disciplinary standards become very important for data retrieval, but also aggregation of relevant data across repositories so research studies are not replicated and that previous results can be reused, verified or replicated.

Figure 6. The Texas Online Data Research Repository. https://data.tdl.org/ The first global academic consortial online research data repository.

Big data and the profusion of data-driven research has also led to new academic library needs regarding size requirements for capture, curation, analysis and preservation of research data. These research data management lifecycles are being championed by academic libraries working largely with their respective university IT centers and various national data storage and computing centers (Digital Preservation Network (DPN), Chronopolis, Texas Advanced Computing Center (TACC), Amazon Web Storage and Services (Freeze, S3), etc.). Curation of datasets becomes increasingly important in this model as does the ability to call up and reuse data, especially with larger data sets. All of this has large implication for academic libraries in their role as facilitators and supporters of the academic research enterprise, especially for the STEM disciplines. Software such as LOCKSS, and organizations such as Duraspace and the Digital Preservation Network (DPN), become increasingly important in terms of organizations championing long-term digital stewardship. Visualization and data visualization literacy also becomes increasingly important in this model especially with the logarithmic increase of data and the human capability and preference for pattern recognition through visual models.

With the evolution of digital repositories also comes challenges of curating and managing specialized disciplinary research. Currently, the OAI-PMH (Open Archive Protocols for Metadata Harvesting) has been established for standardizing information exchange between digital repositories. The larger value of these standards is to be able to aggregate, collocate and synthesize online research whether this is text, data or media. On internet levels, the promise of Tim Berner-Lee's semantic web is finally becoming a reality through 'linked' data and new BIBFRAME standards (Library of Congress, 2017a). The larger idea is that collections and catalogs no longer have to be encapsulated in databases but can be encoded with new standards to be easily searched and retrieved from directly through search engines such as Google. The advantage for academic libraries, and particularly special collections and university

archives with unique items, is that these items can be found immediately and globally by researchers through search engines. Scholars interested in a certain unique text, author or archive can find material instantly. Previously, closed archival documents marked up in Encoded Archival Description Language (Library of Congress, 2017b) can be immediately converted to semantic web BIBFRAME standards for instant linked-data retrieval through Google.

New markup, metadata and media standards are constantly also evolving to enable these types of new technological possibilities. For example, the International Image Interoperability Framework (IIIF, 2017) is a new technological framework standard which allows ancient manuscripts that exist in unique repositories around the globe to be digitized and then collocated in virtual space. A scholar no longer must apply for a grant to travel to the Sorbonne, Oxford, and the Library of Congress to compare online manuscripts, annotations and variants of a work, but can compare them instantaneously online with robust and very powerful imaging zooming functions. These possibilities become fascinating, as the use case scenarios for these technologies range from philology and art history to pulmonary pathology, enabling, for example the examination of say 'pulmonary sarcomas' by a global group of experts, to find consensus and discuss a disease globally, through the sharing of information resources. For the humanities, translations can be accomplished with the three remaining manuscripts of a text by disparate global experts simultaneously, to compare and improve translations and also find consensus in more advanced scholarly social media environments.

With the profusion of information, duplication and 'de-duping' of names, data and literature also becomes important. ORCID has recently emerged as a unique identifier for author names (ORCID, 2017). Unique identifiers can also be attached to particular academic works (permalinks) and permanent data citations online (Universal Numerical Fingerprints). The larger idea is to give the author, work, or piece of data, a permanent internet location, so that other researchers can find the author, quote the relevant work, or, in the case of data, use, reuse or cite the particular

relevant dataset for an experiment and this data will remain 'the same' for all stakeholders. This also leads to the transparency of research, especially with possibilities of data being published and reused.

Figure 7. The evolution of the textbook to online modalities and synthesis with online library resources.

On another level, open access collections and open educational resources (OER) are being adopted by university systems and online universities as potential digital solutions for reducing university textbook costs (Uzwyshyn & Stielow, 2011b). Libraries here act as aggregators of this information and natural partners in working in tandem with faculty specialists to find suitable resources matching university curricula to online possibility. Textbooks, too, are evolving (Figure 7) and framework software, such as Libguides, can create virtual agile textbooks of changing knowledge disciplines (Uzwyshyn, 2012b and 2012c). These online resource frameworks are able to evolve with a quicker pace of knowledge

production than traditional textbook or published article models for curricula. Industry demands for graduates who are current with the latest information and methodologies are also enabled. On higher levels, preprint servers, such as arXiv (Physics, Mathematics) and Biorxiv (Biology), similarly disseminate research papers before official journal submission and publication, establishing precedence for research, but also opening the doors for new avenues of the scholarly record and pre-publication and collaboration possibilities.

EVOLUTION OF THE SCHOLARLY RECORD AND DATABASE

To say the least, the scholarly record is currently going through a paradigm shift. From monographs and articles to blog posts, software, multimedia digital archives and data repositories, the nature of scholarship has changed (New Media Consortium, 12). Within this sea change, academic libraries are also changing to be able to archive, store, access and enable scholars in producing new forms of scholarly work (Uzwyshyn, 2007). Libraries are also in an excellent strategic position with their e-resource holdings to evaluate a scholar's record through new metric, 'altmetric tools' and impact factor tools (Scopus, Scival). They will have key roles to play in both the development of these metrics and storage, preservation and access to a scholar's work. Where previously all of a scholar's output could be kept on a bookshelf, increasingly complex databases are now needed to store and retrieve a scholar's multimedia output. Currently, products such as D-Space, Digital Commons, Islandora Fedora and Hydra are being utilized, but this database storage model is quickly evolving to the cloud and wider areas. For metrics, new groups of powerful analytic tools are available to better evaluate both scholarly output and impact.

Traditionally, academic libraries have purchased databases which aggregated specialized disciplinary content. This expanded in the new millennia to database disciplinary aggregators to create largescale interdisciplinary databases and meta-databases - literally databases of

databases, such as the EBSCO and ProQuest platforms (Uzwyshyn, 2014). From online text aggregation, visual images and media databases have also flourished along with databases that contain 'datasets,' and, increasingly, a combination of all media types (Figure 8).

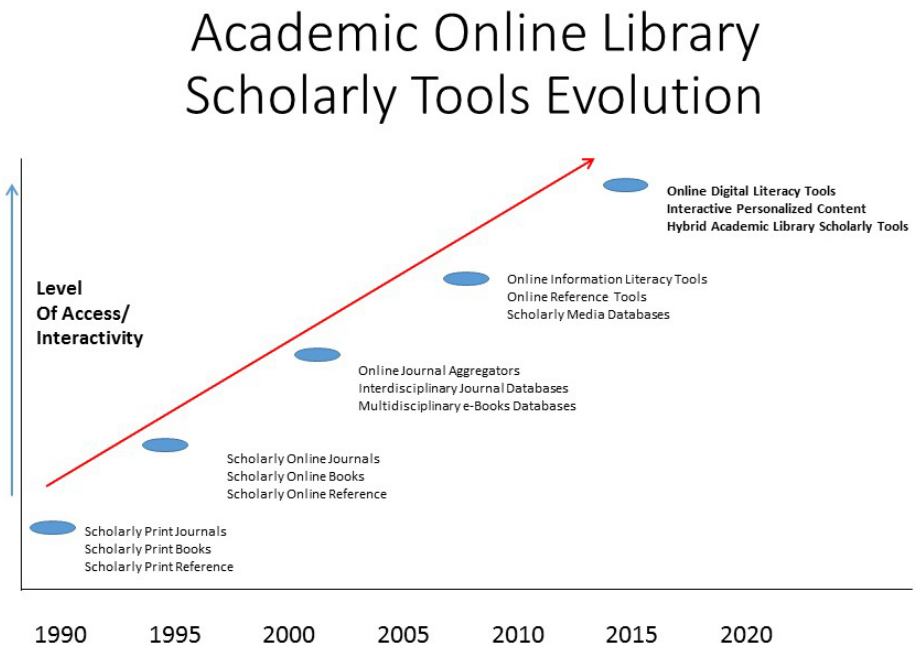

Figure 8. Evolution of online library tools, 1990-2020 with regards to level of interactivity and media range. Graph from Uzwyshyn, 2014.

Another trend in this evolution involves the database becoming an interactive tool, application or software that contains content, but also allows the analysis and manipulation of that content. Datazoa, Curriculum Builder, Browzine, Incites, Plum Analytics, Pure and Artstor Shared Shelf are all good examples where local content may be compared, remixed and repackaged with a particular institution's collections, research and needs (Uzwyshyn, 2014). In Artstor Shared Shelf, for example, visual art history images and text may be aggregated, shared, remixed and synthesized with local collections and needs to create a combined disciplinary database and also tool for art historians or archeologists to create their own collections

and combine their collections with larger databases of the art historical global online digital corpus (Artstor, 2017).

ARTIFICIAL INTELLIGENCE, VR, AR AND GAMES WITH A PURPOSE

It is not difficult to see that many of the topics previously examined in the preceding pages start to become challenging to organize in terms of the library's 21st century evolution. There are several potential pathways forward towards further organizing and clarifying the explosion of databases and the profusion of information. For search methodologies, the application of artificial intelligence and expert systems to improve research processes, learner and researcher outcomes is becoming a viable contender. Online Gaming Methodologies, Human Computation and what Luis von Ahn (2005) has termed 'Games with a Purpose' (GWAP methodologies), show promise both in developing new systems and organizing incredible amounts of previously intractable information (See Uzwyshyn, 2009, von Ahn, 2005). In infancy but also showing potential are VR and AR (Virtual and Augmented Reality) applications and applying these 3D possibilities towards search and retrieval possibilities (Uzwyshyn, 2005 and 2011a).

Currently, IBM Watson is an expert system which shows promise as an early forerunner artificial intelligence system (IBM, 2017). Eventually, these expert AI systems will be married to the traditional library OPAC (Online Public Access Catalog) and EDS (Electronic Discovery System). Currently, our most advanced integrated library systems (Ex Libris Alma, EBSCO Folio) are still evolving to cloud-based methodologies (Ex Libris, 2017; EBSCO, 2017). Both have not yet developed artificial intelligence paradigms for search/retrieval and learning from user feedback. Search strategies, though, will be enabled through AI's increased ability to learn from specialized researchers, but also human computations' ability to

harness multiple users' experience through feedback to create smarter interoperable systems. This will create better learning paths for students but also facilitate researchers' work in retrieval and synthesis of needed information.

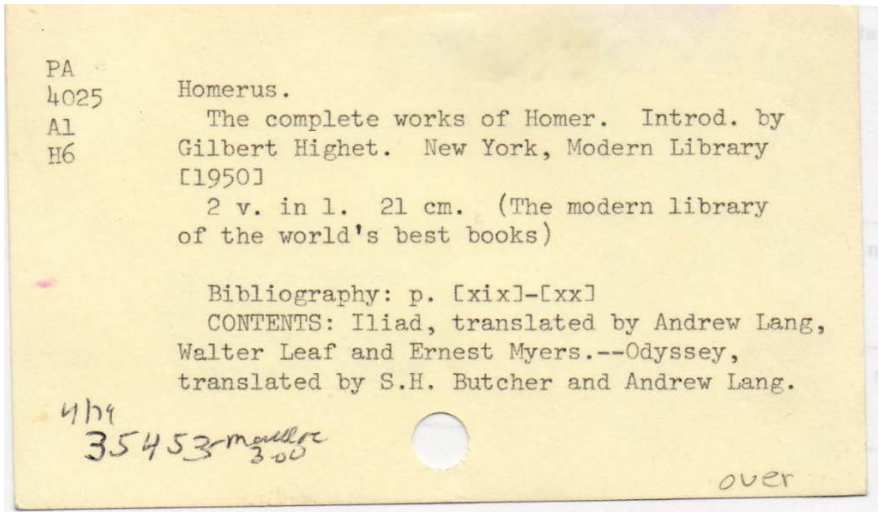

Figure 9. Library of Congress Card Catalog Classification System. The system and card/cabinet were the dominant technologies for search for most of the 20th century.

Presently, online research is still dominated by a PC/mobile- based 'long scrolling' screen list metaphor. It is useful to remember that 'the scroll' idea is an ancient Egyptian tool that produced both the first 'Table of Contents' and numbered list. Also, it is good to remind ourselves that we possess a long collective human history of developing these knowledge seeking tools (Uzwyshyn, 2006, 2011a, Figure 9). Will artificial intelligence provide better metaphors through neural net or other insightful visual-based paradigms for efficacy and facility through which we will navigate our future universes of knowledge? Time will tell.

CONCLUSION

Academic libraries exist today in dynamic changing technological, political and social environments. In the future, these contexts will evolve in our increasingly technocratic global society. A keyword to remember for future academic leaders and libraries is ‘continuum.’ This continuum is necessarily predicated on human resources, more precisely, engaged staff to enthusiastically place themselves in the spectrum of possibilities in a larger sea of information. Academic libraries have never existed in a vacuum. Technologies of the future will evolve in tandem with society. These will continue to vary and range from internet, to learning technologies, to the changing nature of AI, social media, mobile and visualization. The possibilities look progressive with the changing nature of devices, increase of computing power and, so far, very fruitful marriage with academic libraries. We are in exciting times for technology and academic libraries, especially with regards to the evolving record of human knowledge. We need to be vigilant stewards of these archives of knowledge of which we, currently, are the destined executors.

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