Mapping the Current Landscape of Research Library Engagement with Emerging Technologies in Research and Learning:

Furthering Learning and Student Success

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This is the sixth installment of a forthcoming report, *Mapping the Current Landscape of Research Library Engagement with Emerging Technologies in Research and Learning*, that will be published in its entirety by late 2020.

The following installments are being published as they become available at https://doi.org/10.29242/report.emergingtech2020.landscape:

- Executive Summary [published March 26, 2020]
- Introduction, Methodology, and Cross-Cutting Opportunities [published April 2, 2020]
- Facilitating Information Discovery and Use [published April 14, 2020]
- Stewarding the Scholarly and Cultural Record [published May 27, 2020]
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Landscape Overview

Students intersect with a wider range of technologies over the course of their academic careers than ever before. From using electronic lab notebooks in data science courses, to exploring virtual recreations of archaeological sites, to participating in next-generation learning management and analytics systems, students' academic lives are filled with new technologies and new media. These exciting pedagogical opportunities require a range of new digital competencies. Students not only need access to technology, but they need the education to use it in informed and ethical ways. Libraries are natural partners in this process. As third spaces on campus, libraries can democratize access to software and hardware that students may not have through their program of study. Through existing digital fluency programs, libraries can help students understand the implications of using new digital tools and services, and help them critically engage with new media.

Research libraries provide a range of informal education and consultation to impart the digital skills that contribute to the academic and professional success of undergraduates, graduate students, and early career researchers. These include workshops that teach concrete digital scholarship and coding skills, such as programming languages,[1] software carpentry,[2] and data visualization;[3] research data management and open science practices; and scholarly communications topics such as copyright, identity management, and navigating academic publishing. Longer-term cohort-based educational programs have also become popular. These programs often encourage interdisciplinary engagement with an emerging technology over the course of a semester or longer.[4] A few research libraries have also launched formal programs that fill gaps in the academic curriculum, for example, the Temple University Libraries' interdisciplinary cultural analytics certificate.[5] In addition to digital scholarship skills, research libraries have opportunities to help students critically engage with and optimize their use of a new generation of productivity tools, many powered by machine learning (ML), that promise to assist users in a range of tasks related to learning and study.

The ease of publishing information and misinformation on the web, the growing sophistication of counterfeit content, and the use of black-box algorithms to generate and display information mean that achieving digital fluency[6] also requires that students be able to interpret and evaluate an unprecedented array of new media formats and sources. Students not only need to understand the credibility and reliability of textual media, but they also need data and algorithmic literacy skills, strategies for distinguishing between genuine and manipulated or fabricated digital content, and an understanding of online data privacy. Libraries are well-positioned to deliver an expanded digital fluency curriculum in partnership with faculty members, campus IT, and other collaborators. At the campus level, libraries also have a role in advocating for transparent, privacy-aware approaches to learning analytics as institutions increasingly collect sensitive student data at scale for the purposes of evaluating individual students and improving aggregate outcomes.

The following sections highlight some of the most influential technologies related to the learning enterprise, through the lens of the library's involvement in promoting digital fluency, participating in next generation digital learning environments (NGDLEs) and learning analytics initiatives, and supporting a range of new study and productivity tools.

Strategic Opportunities

Build digital fluency and digital scholarship skill sets

Librarians have long held a key role as educators, specifically contributing to information literacy by helping students identify relevant, reliable content. Historically, this has meant imparting strategies for discovering and evaluating suitable resources for their research and learning. The library's role in promoting information literacy has dramatically changed as search behavior has shifted away from the library catalog to web-scale discovery systems. At the same time, the definition of information literacy has significantly expanded

alongside the proliferation of digital media. The ease of publishing information and misinformation on the web, the growing sophistication of counterfeit content, and the use of black-box algorithms to generate and display information means that achieving information literacy now requires students to interpret and evaluate an unprecedented array of new media formats and sources. Students not only need to understand the credibility and reliability of textual media, but they also need data and algorithmic literacy skills, strategies for distinguishing between genuine and manipulated or fabricated digital content, and an understanding of online data privacy.

The Pew Research Center has identified algorithmic literacy as a key societal challenge and cited a comment from one expert who predicted that without purposeful intervention through education, "there will be a class of people who can use algorithms and a class used by algorithms."[7] Whether or not students are aware, algorithms have come to shape their daily experience on the web, with significant implications for digital information discovery. Students routinely utilize "systems that predict, recommend, and speculate about [their] interests" based on their search history, social media engagement, and a host of other esoteric variables, processed through proprietary and opaque algorithms over which they have no control.[8]

Yet many students are unaware of the decisions, motives, and biases underlying search engines, news feeds, and other sources of digital information. Search is often considered a "neutral" activity, and students may take as a given that the content delivered by the search algorithm is the most objectively relevant to their needs.[9] Students are unlikely to receive guidance from their professors that addresses algorithmic literacy, and they may feel ill-prepared to critically engage with algorithmic platforms or resigned to having a lack of control in their digital interactions.[10] This lack of critical engagement with information discovery online has both micro and macro implications. On the level of a single search interaction, an opaque relevancy algorithm will likely influence a student's decision to use one information resource over another. In the grander scheme, "the

immersion of algorithmic culture into everyday life has the potential to shift how decision making is enacted and agency is performed, in addition to what knowledges and ways of knowing are privileged."[11]

Librarians have a dual role in algorithmic literacy: raising awareness of and encouraging students to think critically about the black-box algorithms underlying information tools, and providing students with search strategies and systems that give them agency in the discovery process. Despite significant attention paid to many new digital fluency skills, algorithmic literacy has not yet permeated library school curricula, the ACRL Framework for Information Literacy, and other professional channels.[12] In 2017, the Institute of Museum and Library Services awarded Montana State University a grant that aims to improve algorithmic literacy among librarians, equipping them to better serve their communities. The project's deliverable, an open curriculum on algorithmic literacy, aims to address this gap.

A handful of other consortial and field-level initiatives also aim to establish libraries as leaders in algorithmic literacy. For example, the AI for All initiative, a pan-Canadian project led by Ryerson University Library, Toronto Public Library, and the Canadian Federation of Library Associations, will "design, deliver, evaluate, and sustain an algorithmic literacy program in Canadian public libraries that provides a variety of pedagogical approaches to understanding the key aspects of artificial intelligence (algorithms) and how they affect and empower individuals and society."[13] Project Information Literacy will release a new report in the coming months that aims to provide librarians with a better understanding of the effects of algorithms in the lives of students.[14]

Alongside the algorithms that mediate their digital experiences, students also face an increasingly complex media landscape. They contend with a proliferation of unreliable information, facilitated by the ease of self-publishing on the web, and, increasingly, with fabricated or altered content that can be difficult to identify. ML tools and generative adversarial networks (GANs) have made it increasingly

simple to create altered or completely fabricated content online, from auto-generated text to "deep fake" videos, which are "the product of artificial intelligence or machine-learning applications that merge, combine, replace and superimpose images and video clips" to create a fake product that appears alarmingly authentic.[15] Image and video manipulation are not new, and while individuals coming of age in the digital era have developed a degree of healthy skepticism about the authenticity of visual media online, the sophistication of ML-powered tools enables the creation of fake content with unprecedented speed and perceived legitimacy. This environment leaves students ill equipped to distinguish between genuine and digitally manipulated content, and to determine its origins.[16]

Identifying fabricated and manipulated content is both a technological and social issue. Numerous technological approaches have been developed and deployed to determine the authenticity of video and images online. With each advance, deep fake creators develop new strategies for eluding detection.[17]Regardless of the effectiveness of these technical tools, students require nontechnical strategies for identifying and engaging with altered and fabricated content. Librarians can equip students with strategies for not only spotting suspicious content, but also for asking critical questions about how and why it might have been created, to what ends, and for whose benefit. In order to impart digital visual literacy to students, "It is not so much that we promote paranoia around the content, but alternatively prepare users to engage with technology going forward. We must avoid asserting the products of technology exist in isolation and instead ask how the products got to us in the first place."[18]

Finally, the scope of digital fluency now includes an understanding of how an individual's data is gathered and used on the web. Libraries are considering data privacy a core aspect of information literacy and incorporating it into their teaching.[19] Libraries can educate their communities about online data collection practices, assist students in understanding privacy policies and terms of service, and help their communities become more savvy digital consumers. These efforts may

be particularly necessary given the growing number of commercial e-learning platforms that students may be required to use in their coursework.[20] Libraries can help students understand how such platforms collect and use their data, giving them the tools to advocate for their interests.

New approaches to information and digital fluency emphasize students' role as creators, not just consumers, of digital media. In addition to helping students develop skills in critically using and evaluating algorithmic systems, interpreting data, and spotting deep fakes, libraries are increasingly thinking about how students can become ethical creators of digital media. Bryn Mawr College's Digital Competencies Program, "a tool for students to use to reflect on the digital skills and critical perspectives they develop while in college," is managed by the college's Library and Information Technology Services and places design thinking and "critical making" alongside evaluating digital information sources and data literacy skills.[21]

A new generation of productivity tools, many powered by ML, promises to assist users in a range of tasks related to learning and study. As key resources for information literacy on their campuses, librarians have a role in helping students effectively, ethically, and responsibly select and use these emerging productivity apps. Academic libraries commonly host workshops, online resources, and individual consultation services to help their communities optimize their use of citation management, collaborative authoring, and personal digital information management tools, among others. In the coming decade, students are likely to adopt a growing number of new tools that promise to make learning and research easier, faster, and more productive. These may include voice to text transcription services such as Otter,[22] which uses ML algorithms to not only transcribe audio, but also to identify speakers and extract topics; Beautiful.ai,[23] which helps users create polished slide decks using an ML algorithm; Scholarcy,[24] which automatically summarizes text; or Trevor,[25] which uses AI in the service of task and time management.

These tools have tremendous potential benefits. Voice-to-text transcription, for example, could assist students with note-taking and qualitative research activities, and may be particularly helpful for students with hearing or learning disabilities. Automated text summarization tools could allow students to more easily identify content relevant to a particular assignment or area of interest. On the other hand, these tools entail myriad concerns around user privacy, plagiarism and cheating, and misuse. For example, like all ML-powered services, voice transcription has the potential to compromise user data and privacy. Otter's terms of service explicitly state that the app uses segments of voice recordings and transcriptions for its training corpus. Recordings are uploaded to a cloud server, risking exposure in the event of a hack or human error. Automatic text summarization, translation, and generation apps could make it easy and tempting for students to cut corners on writing assignments.

Library support for productivity tools, through workshops, web-based resources, or other channels, could help community members learn about new ways of streamlining or enhancing their research and study, while also encouraging them to think critically about the implications of using these tools, from understanding terms of use and data privacy, to thinking through how they relate to plagiarism and other ethical concerns. Libraries are also taking a seat at the table in campus-wide discussions about institutional adoption of and policies related to the use of these tools.

Highlighted Initiatives

Information Literacy in the Age of Algorithms report
Project Information Literacy
https://www.projectinfolit.org/algo_study.html
Project Information Literacy recently conducted focus groups with students and faculty at eight universities and colleges to understand "how college students conceptualize the ever-changing online information landscape, and navigate volatile and popular platforms that increasingly employ algorithms to shape and filter content." While students understand and resent that their personal information is being used to shape their online experiences, this topic is "rarely mentioned in the classroom, even in courses emphasizing critical thinking and information literacy."

Privacy Services
Cornell University Library
https://www.library.cornell.edu/services/privacy
Recognizing the centrality of supporting intellectual freedom to the library's mission, Cornell University Library recently unveiled a bundled suite of privacy services for students and faculty. Services include general digital privacy literacy workshops and consultations to help students and faculty identify and mitigate risks to their privacy while engaging in academic and personal activities online, as well as specialized privacy consultations for researchers engaging in particularly sensitive work or in contexts that expose them to increased risk.

Digital Competencies
Bryn Mawr College Library and IT
https://www.brynmawr.edu/digitalcompetencies
The Digital Competencies program at Bryn Mawr is managed by a blended Library/IT organization and blends concepts from the ACRL Framework for Information Literacy for Higher Education with "digital survival skills" and concepts for ethical digital media creation for students. Faculty members have incorporated digital

competencies into their courses, and students are also encouraged to use them to "reflect on their skills, build skills based on their interests, and practice articulating their competencies to different audiences," including future employers.

Integrate with campus-wide platforms and initiatives that advance learning

Next generation digital learning environments are changing the way students engage with their instructors, advisors, peers, course materials, and the library. According to the EDUCAUSE Learning Initiative (ELI), the core features of an NGDLE include "interoperability and integration; personalization; analytics, advising, and learning assessment; collaboration; and accessibility and universal design."[26] NDGLEs comprise a modular network of "pedagogical tools and applications all connected by means of open standards," rather than a single overarching platform.[27] NGDLEs may encompass a learning management system as one component in a broader, dynamic infrastructure.

Yet, unlike learning management systems (LMSs)—which play a relatively passive role as host for digital course materials, discussions, and grades—NDGLEs incorporate adaptive learning and automated advising, risk-detection and predictive analytics, and other technology-enabled tools to actively evaluate and influence student success. For example, University of Notre Dame has implemented the Apereo Open Learning Record Warehouse as a dashboard for compiling student data from a variety of sources into visualizations that can be used to holistically track student progress, using Sakai as an LMS.[28]

Libraries have typically engaged with the LMS by providing links out to library resources, including general search tools and guidance, tailored subject guides, and contact information for subject specialists. Involvement with the LMS has often required significant investment, either in manually maintaining up-to-date resources for the range of individual courses using the system, or in developing dedicated widgets or portals that can function within the LMS environment.[29]

The NGDLE gives libraries an opportunity to not just embed static resources into an external system, but to become a node that dynamically integrates and promotes relevant information and resources at the point of need.

Personalization is one of the core features of an NGDLE. The structure of an NDGLE is defined not only by the institution, but the user. Adaptive learning technologies will dynamically adjust content based on an individual learner's needs and progress, built-in recommendation engines will suggest relevant resources based on a student's courses, and ML-enhanced advising will provide students with individualized guidance throughout their education. Edtech vendors are now building AI into LMS systems, using learner data to study behavioral practices—such as learning styles, emotions, gestures and electro-dermal activation, speech, and online learner behavior types—and deliver personalized content that adapts to "prior learning experiences and performances; self-expressed student preferences in modes of delivery; analytical prediction of likelihood of success for the individual student through different modes of delivery; and much more."[30] In the future, this personalization might include curated library resources relevant to a student's classes or their specific research interests and suggestions for relevant library consulting services or workshops.

Learning analytics (LA) encompasses a range of data collection and analysis activities that "help educators discover, diagnose, and predict challenges to learning and learner success" and design interventions that improve student outcomes.[31] The infrastructure that enables these activities, commonly referred to as integrated planning and advising for student success (iPASS) systems, aggregates data from a range of sources: grades and engagement levels from learning management systems, analytics from electronic learning materials platforms, demographic data from student information systems, and participation in clubs and events from extracurricular involvement systems. Yet, data about engagement with library resources and activities are rarely included.[32]

Learning analytics systems have arisen from a confluence of challenges: increased scrutiny of higher education budgets, intractable student retention issues, and growing student debt loads, among others. The underlying motivation for higher education institutions is to understand which factors contribute to student retention and satisfaction, and which indicate an increased risk of academic failure. Equipped with this information, institutions can address macro- and micro-level challenges, from identifying ways to reduce the cost of education to providing early interventions that help a struggling student succeed in a course.[33]

Learning analytics "focus on leveraging human judgment," providing distilled information to human stakeholders—professors, advisors, administrators—to be combined with observation, dialogue, and interpretation.[34] Analytics represent one piece of a larger puzzle that helps universities understand a student's progress, identify whether and in what ways they are at risk of negative outcomes, and plan the most successful interventions.

iPASS systems enable this type of assessment through the use of both descriptive and predictive analytics. Descriptive analytics quantify a student's behavior (for example, how many hours they interacted with a platform or learning materials), while predictive analytics enable early warning systems to identify students who appear at risk of academic failure. Predictive analytics have come under particular scrutiny for their potential for misuse. One expert interviewed for this report described them as potentially transformative but "fraught with peril."[35]

Within this context, libraries have also come under increasing pressure to quantify their contributions to student success and to contribute data about student interactions with the library to analytics systems that generate a data picture of a student's academic life. Longstanding proxies for library impact such as collections usage, numbers of instruction sessions and consultations, and foot traffic to library buildings are being replaced or complemented by metrics that aim to

understand the role of the library's activities on student outcomes. Studies focused on quantifying the library's contribution to student success have proliferated over the past decade. A meta-analysis of student success studies in libraries identified a 570-percent increase in such studies between 2013 and 2014.[36] Responses to a recent ARL SPEC survey indicated broad uptake of learning analytics activities in libraries. Over 80 percent of respondents reported engaging in "library assessment projects that utilize educational and institutional data, data analysis methods, and share similar goals of other non-library learning analytics work."[37] These activities generally include collecting and analyzing reference, instruction, and circulation data, occasionally in combination with data provided by other campus units.

Despite this trend, academic libraries are not yet systematically participating in or contributing to *campus-wide* learning analytics efforts.[38] One exception, among others, is the DePaul University Library, which collaborated on the development of the campus iPASS system. Among other functions, the system allows faculty and advisers to seamlessly refer students to a librarian for research assistance.[39]

The absence of broad participation in campus-wide initiatives has a number of causes. Central among them is a lack of understanding, within the library and externally, about the relevance of library data to campus-level initiatives. Only half of respondents to the ARL SPEC survey felt that library data was "very important" to learning analytics initiatives at their institution.[40] Outside of the library, administrators used to thinking of the library as a collections-focused entity may not fully grasp its important contributions to student learning.

Data interoperability presents another barrier. Library data may require considerable cleaning and reconciliation to integrate with iPASS systems and with other campus data sets. For libraries opting to participate in iPASS systems, adopting interoperability standards and working with other institutional stakeholders is key to ensuring that library data counts.

Concerns about privacy have also hindered widespread participation. Half of respondents to the SPEC survey identified privacy concerns as a reason they limit which data they share across campus units. Learning analytics are susceptible to the same pitfalls as any big-data practice. Unlike traditional research practice, in which "actors seek consent for data gathering beforehand and use the data as means toward explicitly agreed-upon and respected ends," the affordances of big data encourage actors to collect massive volumes of information without an explicit purpose, and often unbeknownst to the individuals whose data is being collected.[41]

A meta-analysis of 54 studies that utilized library learning analytics data identified inadequate or undefined data security, retention, anonymization, informed consent, and other practices, and a general lack of attention to privacy issues among such studies.[42] Fewer than half of respondents to the ARL SPEC survey "reported having a records-management schedule or policy that controls the retention of learning analytics data."[43]

The impact of learning analytics systems on student success remains unclear. A number of institutions have reported evidence of concrete improvement in retention.[44] However, a literature review of 252 studies of learning analytics system implementations found "little evidence in terms of improving students' learning outcomes," with only 23 of the 252 studies the researchers reviewed presenting evidence of such an effect.[45] A greater proportion of studies (35 percent) found that learning analytics systems had a positive impact on student retention and completion rates.

Whether or not they directly impact student outcomes, LA systems can provide valuable information that helps libraries and other campus units improve services. LA systems can help libraries understand both general patterns (such as which library-related activities correlate with a student's grade point average) and answer specific questions (such as at what time of the semester a library intervention might have the most impact on a student's final grade). Identifying these patterns can lead

libraries to further investigate patterns through qualitative research methods, indicate opportunities to pilot new approaches to service development and implementation, and inform activities that improve the library user experience. Librarians seeking to establish definitive, causative relationships between librarian interactions and student learning and success are unlikely to find quick and easy answers through engagement in learning analytics. Current learning analytics systems are built on correlations, not causations.

Legitimate concerns about potential adverse effects of LA initiatives, from the risk of data reidentification to the misuse of predictive analytics, have led some libraries to dismiss participation as inherently antithetical to library values. Other libraries have explored whether ethical and productive approaches to collecting and using student information are possible given additional investment and oversight, a commitment to transparency and informed consent, precautions against data reidentification, and attention to minimizing adverse effects. The library can bring this perspective to bear in campus conversations. European institutions, bound by the General Data Protection Regulation (GDPR), provide models for implementing these values. Jisc's *Code of Practice for Learning Analytics*, which enumerates the "responsibilities of educational institutions to ensure that learning analytics is carried out responsibly, appropriately and effectively" is a robust resource for libraries looking to influence LA initiatives on their campuses.[46]

If libraries opt out of campuswide or internal LA initiatives, they risk missing out on beneficial insights that can lead to concrete service improvements. They also risk downplaying the library's contributions to student learning and success in the eyes of campus administrators. A more productive approach may be to take a seat at the table, principles in hand.

Highlighted Initiatives

Library Learning Analytics Project
University of Michigan
https://libraryanalytics.org/
The IMLS-funded Library Learning Analytics Project aims to develop extensible best practices for library data "collection, storage and analysis" using University of Michigan student data as a testbed. One of the project's early deliverables is a privacy guide for libraries seeking to ethically collect and use student data.

Student Dashboard
Nottingham Trent University
https://www4.ntu.ac.uk/current_students/studying/student_dashboard/index.html
NTU's Student Dashboard reveals key academic engagement metrics to students in a visual dashboard, including library use, e-book usage, LMS logins, and card swipes into academic buildings. Students can then compare their engagement with an anonymized aggregate of peers in the same course. Exposing this data directly to students enables them to better understand the connections between their own academic engagement and success.

Democratize access to emerging technologies in library spaces

Technology-rich learning and information commons, collaboration studios, makerspaces, and labs are now commonplace in libraries. These spaces provide access to specialized software and hardware for fabrication (such as 3D printers, computer-aided design and drafting software); visualization (such as high-resolution displays); immersive reality (such as virtual reality [VR] headsets); and other digital research and creation methods. The success of these projects depends largely on their ability to bring together sophisticated equipment and software with a range of support services that help users fully exploit these tools and connect them to broader learning outcomes. Equipping a lab with state-of-the-art hardware and software will not on its own create the conditions necessary for students to create, innovate, and learn. When

libraries apply their existing expertise as educators to new forms of knowledge production, they can help their communities thoughtfully and productively engage with technology.

Locating digital scholarship centers within libraries may also help to democratize and de-silo access to cutting edge technologies, encouraging cross-disciplinary collaboration and discovery.[47] While the hardware and software available in a library makerspace may be available to subsets of students through their department or college, in many cases the library is the only place that provides access to the entire campus community, regardless of affiliation. Asked about the rationale for building a new AI-focused lab at the University of Rhode Island Libraries, dean of libraries Karim Boughida explained, "When you have an AI lab in a specific college, the impression is that access is only for students of that college. Even if students are told they can use the space, there may be a percentage that may feel unwelcome, or that it is 'not for me.' In the library it will be different."[48]

Many digital scholarship centers help build research communities of practice within the library building by offering semester-long fellowships to faculty and graduate students, hosting longer-term projects or interest groups, and creating durable research outputs that highlight collaboration between librarians, technologists, and disciplinary experts. These longer-term projects complement one-off workshops and events to create programs that are responsive to rapidly evolving needs and interests. The combination of access to software and hardware, collaboration space, and technology expertise has proved compelling to faculty members, bringing them back into the library building.

While many library makerspaces, digital scholarship centers, and labs support a wide range of technologies, libraries are paying particular attention to immersive reality and data science support.

Immersive reality studios

The presence of immersive reality technologies in libraries has grown significantly as academic institutions recognize the pedagogical and research applications of augmented, virtual, and mixed reality (AR, VR, and MxR). Often collectively referred to as immersive reality, these technologies "enable faculty and students to engage with highly detailed 3D data—from cultural heritage artifacts to scientific simulations—in new ways."[49] Immersive reality can enhance learning experiences by allowing students and scholars to manipulate "rare, fragile, endangered, or microscopic"[50] resources or engage with remote, inaccessible, fictive, or ancient environments.[51] MxR may hold particular pedagogical potential because of its ability to blend "virtually reconstructed cultural content" with "physical cultural heritage elements at their natural location."[52] Libraries and cultural heritage institutions seem particularly well positioned to take the lead in pedagogical applications of MxR given their dual roles as educators and as stewards of cultural and historical artifacts.

The release of affordable, consumer-grade VR headsets and other technologies required to create and experience immersive reality environments has reduced barriers to entry and led to a boom in interest among libraries. While many academic libraries now have small collections of VR headsets for lending, only a few have started building full-fledged programs for immersive reality support. The University of Oklahoma (OU) Libraries's The Edge studio, public VR spaces at the University of Virginia (UVA) Library, and the TRAIL collaboration space at the University of Washington (UW) Health Science Library provide three noteworthy examples of immersive reality spaces as collaborative endeavors with explicit links to the undergraduate curriculum (in the case of OU and UVA) and faculty research (at UW).

At The Edge, a library-based makerspace, the OU Libraries have installed several VR terminals consisting of "a moveable chair-on-rails, coupled with a high-end gaming PC and an Oculus Rift HMD (head

mounted display)."[53] The libraries have worked with classes in multiple disciplines to develop custom learning software and deploy it in the undergraduate curriculum. A recent course collaboration brought together students from three university campuses to collectively explore a VR environment simulating a remote cave otherwise inaccessible to the public.[54] The use of VR also allowed students to adjust lighting, zoom, and explore the environment in other ways that would be difficult in the physical world. The OU Libraries have found that incorporating VR into select courses had "significant positive impact on self-efficacy along dimensions related to completion of spatial tasks," an indication that VR can support learning outcomes, particularly in spatially oriented fields such as architecture.[55]

At UVA, a VR lab in the library invites students to engage spatially with research topics. Using the Unity VR platform, "a research topic is represented spatially by creating 'rooms' in a virtual museum that relate to the arguments in a paper. The details of the argument are expressed by images, text, audio, or video objects placed in a room much like objects in a museum exhibition."[56]

At UW Health Science Libraries, the TRAIL collaboration space originated as a general purpose translational research lab backed by the library' clinical information program and IT services.[57] When a faculty member reached out to the library with a specific request to test VR on the existing data wall, the library took the opportunity to consider how the space could accommodate VR experimentation on a larger scale. The library has generalized its planning process into a comprehensive toolkit for VR spaces design in libraries. The toolkit addresses both technical design considerations and theoretical concerns, ranging from the minimum and maximum room scale specifications based on the types of VR headsets employed to how library VR spaces in health science libraries can effectively protect patient privacy.

The growth of immersive reality spaces and services in libraries is yet another indication of the library's burgeoning role in "experimentation and knowledge production," and a promising avenue for libraries

to demonstrate continued relevance as "both as the custodian and curator of all forms of research and educational data, and as a catalyst for innovation in scholarship and pedagogy."[58] Immersive reality initiatives, which require close partnerships between technologists and disciplinary experts, further reinforce the library's role as a hub for cross-disciplinary collaboration.

Data science centers

Data science programs have seen dramatic growth over the past several years, as universities hurry to keep pace with student interest and industry demand for skilled data scientists. The highly interdisciplinary nature of data science as a field requires new models of support services. Data science courses and programs are often established outside of existing departments[59] and draw in learners from a range of academic backgrounds and majors beyond computer science."[60]

In order to provide cross-disciplinary opportunities for students to deepen and apply their data science skills, some campuses are creating dedicated spaces equipped with the appropriate software, hardware and associated programming. For example, the Moore-Sloan Data Science Environments (MSDSE) project, initiated in 2015, sponsored the development of three data science environments" (DSEs) at New York University (NYU), the University of Washington and the University of California-Berkeley.

All three DSEs were established outside of existing departments; two of the campuses (NYU and UW) selected the library to host the new space.[61] Libraries were considered ideal sites given their commitment to interdisciplinarity and openness, two core characteristics of data science research, and the perception of libraries as neutral or third spaces without ties to specific departments or programs on campus, or external parties such as corporate research sponsors. Positioning data science centers in libraries or other neutral spaces, rather than within professional degree programs whose goals are primarily to prepare students for the job market, may result in different focuses and priorities.

The data science centers established through the MSDSE project, for example, all developed a focus on the ethical implications of data science and its contributions to the public good, even though this was not an explicit goal at the outset.[62] At URI, which recently established a first-of-its-kind library-based AI lab, the mission, according to chief technology officer for University Libraries Bohyun Kim, is "to help students and faculty learn about and navigate all of the discussions and issues around AI. The goal is a lot broader than just pure scientific research."[63]

Labs situated in libraries can also contribute to de-siloing data science support services and making them more inclusive of all skill levels and majors. While formal instruction in data science is often targeted to students in STEM fields, many labs explicitly strive to offer programming appropriate for students from a range of disciplinary backgrounds. The AI lab at URI, for example, will offer instruction for all skill levels in "robotics, natural language processing, smart cities, smart homes, the internet of things, and big data."[64]

Highlighted Initiatives

Artificial Intelligence Lab
University of Rhode Island Libraries
https://web.uri.edu/ai/

The URI Libraries' AI Lab provides all students access to tools such as high-performance computing for developing machine learning applications, along with services such as robotics and AI workshops. The lab team includes librarians along with faculty from humanities and STEM disciplines and has enhanced campus learning by serving as a site for a diverse range of URI courses, from the Wearable Internet of Things to Intro to Philosophy.

The Edge
University of Oklahoma Libraries
https://libraries.ou.edu/content/edge

The University of Oklahoma Libraries support the use of VR and visualization throughout their curriculum and faculty research through multiple spaces on campus, including The Edge. The Edge combines makerspace technologies such as 3D printing and microcontrollers with VR workstations and headsets for VR experiences and creation. The Oklahoma Virtual Academic Laboratory (OVAL) project has been used by faculty and students to collaboratively explore immersive virtual environments.

Translational Research & Information Lab (TRAIL)
University of Washington Health Sciences Library
https://hsl.uw.edu/trail/

The TRAIL space at University of Washington Health Sciences Library provides a suite of technologies and services to students, researchers, and physicians so they can incorporate VR, visualization, virtual computing environments, and data analysis into their practice. In 2018, the HSL received an IMLS grant to "design and build a Virtual Reality (VR) and Augmented Reality (AR) program and studio for surgical care teams to simulate cardiac surgery in a

library environment", which also led to the release of Virtual Reality in Academic Health Sciences Libraries: A Primer, which provides detailed guidance on best practices for creating a library VR space, including room requirements, headset and software options, and other specifications.

Key Takeaways

1. **Librarians can leverage existing skills in search and protecting patron privacy to promote new digital literacies.** As librarians teach students to navigate increasingly complex and opaque search interfaces, they have the opportunity to promote algorithmic literacy and help students ask questions about how unseen algorithms shape the results. Librarians have long cared deeply about patron privacy and intellectual freedom, and can leverage this knowledge to develop privacy-as-a-service workshops to educate students on managing and protecting their identity and personal information online.
2. **Libraries will help students evaluate and responsibly create digital content in an environment of malicious Twitter bots and deep fakes.** Libraries must continue to help students develop skills in evaluating sources, which will entail continuing engagement with constantly evolving new media. Even as the technological medium changes, the same questions of authorship, reliability, and who benefits from false or misleading information will apply. Deeper learning opportunities can come about for students who create digital content, whether in a library makerspace or in a librarian-led workshop. Librarians could promote thoughtful engagement with new technologies by leading workshops on creating Twitter bots so students can understand how emerging technologies can be used and misused.
3. **Libraries must engage with campus learning analytics initiatives or risk being left out of the conversation.** Many campuses are engaged in broad initiatives to measure and predict student success using a wide variety of data sources, but libraries are often reluctant to participate because they believe library data isn't relevant or are

concerned about student privacy. By having a seat at the learning analytics table, librarians can show administrators how they play a crucial role in teaching, learning, and student success while advocating for privacy-aware student data practices on campus.

Endnotes

1. Jeffrey C. Oliver et al., "Data Science Support at the Academic Library," *Journal of Library Administration* 59, no. 3 (2019): 241–57, https://doi.org/10.1080/01930826.2019.1583015.

2. Thea P. Atwood et al., "Joining Together to Build More: The New England Software Carpentry Library Consortium," *Journal of eScience Librarianship* 8, no. 1 (2019): e1161, https://doi.org/10.7191/jeslib.2019.1161; see also "Foundations for Research Computing: A University-wide Initiative," Columbia University, accessed February 19, 2020, https://rcfoundations.research.columbia.edu.

3. Lisa M. Federer and Douglas J. Joubert, "Providing Library Support for Interactive Scientific and Biomedical Visualizations with Tableau," *Journal of eScience Librarianship* 7, no. 1 (2018): e1120, https://doi.org/10.7191/jeslib.2018.1120.

4. Victoria Szabo, "Collaborative and Lab-Based Approaches to 3D and VR/AR in the Humanities," in *3D/VR in the Academic Library: Emerging Practices and Trends*, ed. Jennifer Grayburn et al. (Arlington, VA: Council on Library and Information Resources, February 2019), https://www.clir.org/pubs/reports/pub176/; also see, for example, "The 99 AI Challenge," University of Toronto Libraries, accessed February 19, 2020, https://onesearch.library.utoronto.ca/ai-challenge.

5. Morgan Zalot, "Temple Libraries Launches Interdisciplinary Cultural Analytics Certificate," *Temple Now*, June 3, 2019, https://news.temple.edu/news/2019-06-03/temple-libraries-launches-interdisciplinary-cultural-analytics-certificate.

6. Jennifer Sparrow, "Digital Fluency: Preparing Students to Create Big, Bold Problems," *EDUCAUSE Review* 53, no. 2 (March/April 2018): 54, https://er.educause.edu/articles/2018/3/digital-fluency-preparing-students-to-create-big-bold-problems.

7. Lee Rainie and Janna Anderson, "Code-Dependent: Pros and Cons of the Algorithm Age," Pew Research Center, February 8, 2017, https://www.pewresearch.org/internet/2017/02/08/code-dependent-pros-and-cons-of-the-algorithm-age/.

8. Jason A. Clark, "Building Competencies Around Algorithmic Awareness" (presentation, Code4Lib, Washington, DC, February 15, 2018), Clark's website, https://www.lib.montana.edu/~jason/talks/algorithmic-awareness-talk-code4lib2018.pdf.

9. Olof Sundin, "Critical Algorithm Literacies: An Emerging Framework" (presentation, ECREA Digital Culture and Communication Section Conference, Brighton, UK, 2017), https://portal.research.lu.se/ws/files/35242070/Extended_abstract_Sundin.pdf.

10. Alison J. Head, Barbara Fister, and Margy MacMillan, *Information Literacy in the Age of Algorithms: Student Experiences with News and Information, and the Need for Change* (Project Information Literacy Research Institute, January 15, 2020), https://projectinfolit.org/pil-public-v1/wp-content/uploads/2020/08/algoreport.pdf.

11. Annemaree Lloyd, "Chasing Frankenstein's Monster: Information Literacy in the Black Box Society," *Journal of Documentation* 75, no. 6 (2019): 1475–85, https://doi.org/10.1108/JD-02-2019-0035.

12. Jason Clark, Lisa Janicke Hinchliffe, and Scott Young, " 'RE:Search'—Unpacking the Algorithms That Shape Our UX," Institute of Museum and Library Services, 2017, https://www.imls.gov/sites/default/files/grants/re-72-17-0103-17/proposals/re-72-17-0103-17-full-proposal-documents.pdf.

13. AI for All website, accessed October 6, 2020, https://aiforall.ca/.

14. Head, Fister, and MacMillan, *Information Literacy in the Age of Algorithms*.

15. Marie-Helen Maras and Alex Alexandrou, "Determining Authenticity of Video Evidence in the Age of Artificial Intelligence and in the Wake of Deepfake Videos," *The International Journal of Evidence & Proof* 23, no. 3 (2019): 255–262, https://doi.org/10.1177/1365712718807226.

16. Charlie Harper, "Machine Learning and the Library or: How I Learned to Stop Worrying and Love My Robot Overlords," *Code4Lib Journal*, no. 41 (2018), https://journal.code4lib.org/articles/13671.

17. Jacquelyn Burkell and Chandell Gosse, "Nothing New Here: Emphasizing the Social and Cultural Context of Deepfakes," *First Monday* 24, no. 12 (2019), https://doi.org/10.5210/fm.v24i12.10287.

18. Travis L. Wagner and Ashley Blewer, " 'The Word Real Is No Longer Real': Deepfakes, Gender, and the Challenges of AI-Altered Video," *Open Information Science* 3, no. 1 (2019): 32–46, https://doi.org/10.1515/opis-2019-0003.

19. Harper, "Machine Learning."

20. Clifford A. Lynch, "Reader Privacy: The New Shape of the Threat," *Research Library Issues*, no. 297 (2019): 7–14, https://doi.org/10.29242/rli.297.2.

21. "Digital Competencies: Building 21st Century Skills in a Small Liberal Arts College Setting," Bryn Mawr College, accessed June 10, 2020, https://www.brynmawr.edu/digitalcompetencies.

22. Otter website, accessed October 6, 2020, https://otter.ai/login.

23. Beautiful.ai website, accessed October 6, 2020, https://www.beautiful.ai/.

24. Scholarcy website, accessed October 6, 2020, https://www.scholarcy.com/.

25. Trevor website, accessed October 6, 2020, https://www.trevorai.com/.

26. *7 Things You Should Know About NGDLE*, (EDUCAUSE, December 9, 2015), https://library.educause.edu/resources/2015/12/7-things-you-should-know-about-ngdle.

27. Megan Oakleaf and Malcolm Brown, "The Academic Library and the Promise of NGDLE," *EDUCAUSE Review*, August 14, 2017, https://er.educause.edu/articles/2017/8/the-academic-library-and-the-promise-of-ngdle.

28. Pat Miller and Xiaojing Duan, "NGDLE Learning Analytics: Gaining a 360-Degree View of Learning," *EDUCAUSE Review Transforming Higher Ed Blog*, January 30, 2018, https://er.educause.edu/blogs/2018/1/ngdle-learning-analytics-gaining-a-360-degree-view-of-learning.

29. Meredith Farkas, "Libraries in the Learning Management System," *ALA and ACRL Instruction Section Tips and Trends* (Summer 2015), https://acrl.ala.org/IS/wp-content/uploads/2014/05/summer2015.pdf.

30. Ray Schroeder, "Adaptive Learning to Personalized Learning," *Inside HigherEd Blog*, September 4, 2019, https://www.insidehighered.com/digital-learning/blogs/online-trending-now/adaptive-learning-personalized-learning.

31. Megan Oakleaf, *Library Integration in Institutional Learning Analytics*, (EDUCAUSE, 2018), https://library.educause.edu/resources/2018/11/library-integration-in-institutional-learning-analytics.

32. Oakleaf, *Library Integration*.

33. Sakina Alhadad et al., *The Predictive Learning Analytics Revolution: Leveraging Learning Data for Student Success* (EDUCAUSE Center for Analysis and Research, October 6, 2016), https://library.educause.edu/resources/2015/10/the-predictive-learning-analytics-revolution-leveraging-learning-data-for-student-success.

34. Olga Viberg et al., "The Current Landscape of Learning Analytics in Higher Education," *Computers in Human Behavior* 89 (December 2018): 98–110, https://doi.org/10.1016/j.chb.2018.07.027.

35. Megan Oakleaf, interview by author, November 12, 2019.

36. Kyle M. L. Jones, "'Just Because You Can Doesn't Mean You Should': Practitioner Perceptions of Learning Analytics Ethics," *portal: Libraries and the Academy* 19, no. 3 (2019), preprint, posted May 14, 2019, https://papers.ssrn.com/abstract=3372591.

37. Michael R. Perry et al., *SPEC Kit 360: Learning Analytics* (Washington, D.C.: Association of Research Libraries, September 4, 2018), https://publications.arl.org/Learning-Analytics-SPEC-Kit-360/.

38. Oakleaf, *Library Integration*.

39. Oakleaf and Brown, "The Academic Library."

40. Perry et al., *SPEC Kit 360*.

41. Kyle M.L. Jones and Dorothea Salo, "Learning Analytics and the Academic Library: Professional Ethics Commitments at a Crossroads," *College & Research Libraries* 79, no. 3 (April 2018): 304–323, https://doi.org/10.5860/crl.79.3.304.

42. Kristin A. Briney, "Data Management Practices in Academic Library Learning Analytics: A Critical Review," *Journal of Librarianship and Scholarly Communication* 7 (2019): eP2268, https://doi.org/10.7710/2162-3309.2268.

43. Perry et al., *SPEC Kit 360*.

44. Paul Dosal, "Culture, Care, and Predictive Analytics at the University of South Florida," *EDUCAUSE Review*, December 9, 2019, https://er.educause.edu/articles/2019/12/culture-care-and-predictive-analytics-at-the-university-of-south-florida; Phil Richards and Joel Mullan, "How Universities Can Use Learning Analytics to Boost Fair Access and Retention," *Jisc Blog*, April 11, 2017, https://web.archive.org/web/20180123092707/https://www.jisc.ac.uk/blog/how-universities-can-use-learning-analytics-to-boost-fair-access-and-retention-11-apr-2017.

45. Viberg et al., "The Current Landscape."

46. Niall Sclater and Paul Bailey, "Code of Practice for Learning Analytics," Jisc, June 4, 2015, https://www.jisc.ac.uk/guides/code-of-practice-for-learning-analytics.

47. Joan Lippincott and Diane Goldenberg-Hart, *Digital Scholarship Centers: Trends & Good Practice* (Washington, DC: Coalition for Networked Information 2014), https://www.cni.org/wp-content/uploads/2014/11/CNI-Digitial-Schol.-Centers-report-2014.web_.pdf.

48. Lindsay McKenzie, "A New Home for AI: The Library," *Inside Higher Ed*, January 17, 2018, https://www.insidehighered.com/news/2018/01/17/rhode-island-hopes-putting-artificial-intelligence-lab-library-will-expand-ais-reach.

49. Zack Lischer-Katz et al., "Introduction. 3D/VR Creation and Curation: An Emerging Field of Inquiry," in *3D/VR in the Academic Library: Emerging Practices and Trends*, ed. Jennifer Grayburn et al. (Arlington, VA: Council on Library and Information Resources, February 2019), https://www.clir.org/pubs/reports/pub176/.

50. Matt Cook, Julie Griffin, and Robert McDonald, "Developing Library Strategy for 3D and VR Collections," https://events.educause.edu/annual-conference/2018/agenda/developing-library-strategy-for-3d-and-virtual-reality-collections.

51. Szabo, "Collaborative and Lab-Based Approaches."

52. Mafkereseb Kassahun Bekele and Erik Champion, "A Comparison of Immersive Realities and Interaction Methods: Cultural Learning in Virtual Heritage," *Frontiers in Robotics and AI* 6 (2019), https://doi.org/10.3389/frobt.2019.00091.

53. Zack Lischer-Katz, Matt Cook, and Kristal Boulden, "Evaluating the Impact of a Virtual Reality Workstation in an Academic Library: Methodology and Preliminary Findings," *Proceedings of the Association for Information Science and Technology* 55, no. 1 (2018): 300–308, https://doi.org/10.1002/pra2.2018.14505501033.

54. Dian Schaffhauser, "Multi-Campus VR Session Tours Remote Cave Art," *Campus Technology*, October 9, 2017, https://campustechnology.com/articles/2017/10/09/multi-campus-vr-session-tours-remote-cave-art.aspx.

55. Lischer-Katz, Cook, and Boulden, "Evaluating the Impact."

56. Will Rourk, "3D Cultural Heritage Informatics: Applications to 3D Data Curation," in *3D/VR in the Academic Library: Emerging Practices and Trends*, ed. Jennifer Grayburn et al. (Arlington, VA: Council on Library and Information Resources, February 2019), https://www.clir.org/pubs/reports/pub176/.

57. Michael T. Moore et al., "Virtual Reality in Academic Health Sciences Libraries: A Primer," 2018. https://digital.lib.washington.edu/researchworks/handle/1773/42765.

58. Lischer-Katz et al., "3D/VR Creation and Curation."

59. Jennifer Muilenburg and Judy Ruttenberg, "New Collaboration for New Education: Libraries in the Moore-Sloan Data Science Environments," *Research Library Issues*, no. 298 (2019): 16–27, https://doi.org/10.29242/rli.298.3.

60. Isha Salian, "Universities Rush to Add Data Science Majors as Demand Explodes," *San Francisco Chronicle*, September 5, 2017,

https://www.sfchronicle.com/business/article/Universities-rush-to-add-data-science-majors-as-12170047.php.

61. Muilenburg and Ruttenberg, "New Collaboration for New Education."

62. Ibid.

63. Matt Enis, "University of Rhode Island Opens AI Lab in Library," *Library Journal*, September 26, 2018, https://www.libraryjournal.com?detailStory=180926URIlibraryAIlab.

64. McKenzie, "A New Home for AI."