

MOVING BEYOND OPEN ACCESS TO DIGITAL FLUENCY: THE OPPORTUNITIES TO CREATE AN INFORMATION ENVIRONMENT FOR TOMORROW'S SCIENCE*

MARY LEE KENNEDY

I. WHY THIS IS AN IMPORTANT TOPIC NOW

The conditions under which scholar's knowledge is created, shared, applied, and preserved are in transformation. Here are four reasons why this topic matters now.

1. We are experiencing significant growth in the number of connected devices (8.4B in 2017 –up 31% from last year¹) and in data– (expected to grow to 163 ZB by 2025, 10 times the amount today). Most of this data will be owned and used by enterprises². Most new data isn't publicly available, and

* Conferencia inaugural del congreso Ecosistemas del Conocimiento Abierto (ECA 2017), celebrado en Salamanca los días 25, 26 y 27 de octubre de 2017. ECA 2017 agrupó tres jornadas académicas: 11.º Coloquio Internacional de Ciencias de la Documentación, 16.º Workshop de REBIUN de Proyectos Digitales y 7as Jornadas OS-Repositorios.

¹ <http://www.gartner.com/newsroom/id/3598917> (accessed September 30, 2017).

² <http://www.information-age.com/data-forecast-grow-10-fold-2025-123465538/> (accessed September 30, 2017).

when it is, a small proportion is used. Algorithms may or may not make it easier to decide whether it is worth using – if we understand them. And, at the same time, libraries have a significant amount of knowledge in previous formats that we cannot afford to preserve and make accessible.

2. There is a new generation of potential scholars and they aren't millennials. Millennials are young adults now (they have been since 2000). Future generations of scholars, will emerge from the next generation, Generation Z, a population expected to reach 2.56 billion individuals globally by 2020. And with their arrival we will see the departure of most of the baby boomers. One key fact about Generation Z – they have an average attention span of 8 seconds as compared to the 12 second attention span of millennials³.

3. A 2012 study by Ithaka S&R found that a minority in all scholarly disciplines thought it was crucial to participate in using models, simulations, GIS tools, developing software, or text-mining. A lot has changed since then – upward trends in digital scholarship labs, centers, and institutes, significant demand for data scientists and, the explosion of the Internet of Things. It's time for a new study.

4. With our natural tendency for innovation and the significant implications for life as we know it – we continue to struggle with a shared agreement on the principles, policies, and parameters for ethical research, digital rights, and individual rights to privacy, security, and safety.

2. KEY ASSUMPTIONS

It may be a little odd that the title starts with the words, «beyond open access», given how this remains very much a critical direction for all of us. Open Access remains a shared objective, with emerging economic models, and yet uneven practices. For instance, while the European Union has mandated that all journal articles stemming from its publicly-funded research must be published open access starting in the year 2020⁴, this type of political pressure is not easily achievable in other geopolitical settings.

³ <http://mediakix.com/2017/03/the-generation-z-statistics-you-should-know/#gs.OKcoElo> (accessed September 30, 2017).

⁴ <http://www.stm-publishing.com/open-access-trends-2017-challenges-and-opportunities/> (accessed September 30, 2017).

For today's exploration – let's assume that in our lifetimes there is neither a fully closed nor open scholarship environment. Furthermore, let's assume a few other variables that affect the future:

- There will be many scholars and researchers without tenure, and therefore scholars and researchers will define their professional role in new contexts – adjuncts in universities, governments, for-profit, etc.
- There will be adjustments in assessment and credit i.e. peer review and advancement.
- There will be an increased focus on ethics due to increased consequences for humankind.
- Funding will remain a mixed environment of private and public sources – with significant debates over data ownership.

These all deserve our attention and active engagement – but let's accept them as assumptions in the future world in which we create opportunities for digital fluency. By digital fluency I mean the ability to select tools, know what to do with them, explain why they work in the way they do, and how scholars might adapt the digital research if the context were to change. In essence, research that could not be carried out without technology and scholars know when and why to use it.

Today I'm going to focus on two factors that will affect our role in creating opportunities for digital fluency.

The two factors are:

- The nature of digital scholarship in our lifetime.
- Scholars future preferences for digital scholarship in our lifetime.

I will conclude with what these mean for digital fluency and tomorrow's information environment, specifically our role.

3. THE NATURE OF DIGITAL SCHOLARSHIP IN OUR LIFETIME

The Scholarly Communication Institute defines digital scholarship as: «the use of digital evidence and method, digital authoring, digital publishing, digital curation and preservation, and digital use and reuse of scholarship»⁵.

This is very much a definition focused on the digital-ness of scholarly processes – process names that will be as familiar to us with or without

⁵ SMITH RUMSEY, A. (2011). *Scholarly Communication Institute 9: NewModel Scholarly Communication: Road Map for Change*. Charlottesville, VA: University of Virginia Library. <http://www.uvasci.org/wpcontent/uploads/2011/04/SCI9report.pdf>.

«digital» in front of them: evidence, method, authoring, publishing, curating, preserving, using and reusing.

The *nature* of digital scholarship is experienced differently than in the physical world, differently across disciplines, even within disciplines and among individuals. Rather than starting to explore the nature of digital scholarship from the point of its definition, it may be better understood in the context of Ernest Boyers seminal work on scholarship. His work puts the scholar and his or her work at the center of our conversation⁶.

Boyer identifies four types of scholarship:

1. The scholarship of discovery, covering original research that advances knowledge – often through journals and books.
2. The scholarship of integration that involves the synthesis of information across disciplines, across topics within a discipline, or across time.
3. The scholarship of application (also called the scholarship of engagement) that goes beyond a single faculty member to include others in or outside of the University in the rigor and application of disciplinary expertise that can be shared with and/or evaluated by peers.
4. The scholarship of teaching and learning that systematically studies teaching and learning processes. This is not to be confused with scholarly teaching.

In 2014, Edward Ayers, then President of the University of Richmond, Virginia, a US presidential appointee to the National Council on the Humanities, and a pioneer in the digital humanities, added a fifth type of scholarship –one that is ripe for the digital scholarship world–generative scholarship. He defined it as: «scholarship built to generate, *as it is used*, new questions, evidence, conclusions, and audiences»⁷.

Ayers, was particularly interested in generative scholarship since it captures the ability to work across all disciplines, in big-data projects in science and social science, as well as in focused humanities projects. As he put it, «By using carefully monitored crowdsourcing, institutional collaboration, and social media, generative scholarship can greatly accelerate and deepen the scholarly conversation»⁸.

Let's take a look at what the nature of digital scholarship in our lifetimes could be through the lens of these five types of scholarship. And by doing that, we can set the scene for scholars' digital fluency and for our

⁶ BOYER, E. L. (1996). From scholarship reconsidered to scholarship assessed. *Quest*, 48(2), 129-139.

⁷ <https://www.aacu.org/publications-research/periodicals/future-scholarship> (accessed September 30, 2017).

⁸ *ibid.*

role in creating the information environment that provides opportunities for scholars, and those who benefit from their work.

It's only been 28 years since the World Wide Web was invented. That is very recent if we accept that the Redwood Forest trees live for over 2000 years, let alone in the context that metric expansion of space is estimated to have begun 13.8 billion years ago. In the short span of 28 years, scholars have moved from:

- Consulting paper reference books to using Google scholar as one of their primary search tools.
- Research limited to the resources at the desk to resources around the world.
- Computational power in one computer to significant computational power in the cloud.

For a moment, consider how this one innovation has challenged academic principles, policies, and scholars practices.

This has not been a journey without controversy. Some examples will serve to make the point:

- Personal privacy and Internet behavior.
- Algorithms⁹ reflecting human bias and racist views.
- Data breaches in financial institutions.

Now consider the current technology revolution – one dominated by artificial intelligence, robotics, and sensors that connect devices through the «Internet of Things». According to technology futurists and experts, our experience of the last 28 years is nothing compared to the changes we are just beginning to experience. Here are some recent developments aligned with Boyer's types of scholarship:

- Discovery – Space probe to Mars¹⁰.
- Integration – Google Correlate finds search patterns which correspond with real-world trends.
 - Application – Genetically modified astronauts¹¹ [CRISPR].
 - Teaching and Learning – Research on pedagogical agents.
 - Generative – Oral histories such as <http://mukurtu.org>.

⁹ <https://www.theguardian.com/technology/2017/apr/13/ai-programs-exhibit-racist-and-sexist-biases-research-reveals> (accessed October 9, 2017).

¹⁰ https://starchild.gsfc.nasa.gov/docs/StarChild/space_level2/mars.html (accessed October 9, 2017).

¹¹ <https://www.technologyreview.com/s/604142/engineering-the-perfect-astronaut/> (accessed September 30, 2017).

We can learn from the past to inform how we best create an information environment to support scholar's work in the future. I will highlight four particularly important lessons for future digital fluency.

1. Digital disruptions are a given. In tomorrow's world most scholarship will be, or will include, significant elements of digital scholarship.
2. Technology innovation adoption is highest when it meets human expectations. Convenience was a significant factor in Internet adoption. Expectations of future technologies will likely include:
 - Immediate insight into complexity.
 - Personalized relevance.
 - Breakthroughs in previously incomprehensible subjects.
 - New states of physicality.
3. There are always constraints and so tensions will also exist. The research community may experience more pronounced tensions in:
 - Private and public research funding and ownership of the intellectual property.
 - Interdisciplinary collaboration.
 - Reproducibility and integrity.
 - Research methods and ethical practices.
4. Most humans capacity for learning is slower than many machines. We can expect that the need for changes in digital competencies (skills and knowledge) will occur at a speed much faster than in the past. Our cognitive flexibility may be taxed as we move to settings that require significant judgement and decision-making, and complex problem solving; and trust in innovations that in themselves will open up new fields of inquiry.

In this evolving, perhaps even revolutionary change, in scholarship, there will be many critical players. Today I am focusing on two – the scholars and those who are collaborative partners and stewards of their work.

4. SCHOLARS AND DIGITAL SCHOLARSHIP IN OUR LIFETIME

Potential and future scholars will enter their fields with the departure of most of the baby boomers, fewer tenure-track positions, and, not always, but often, collaborative teams of interdisciplinary researchers working on

complex issues. There may even be increased attention on teaching – something most Ph.D. programs do not focus on today¹². For certain there will be many technological choices raising ever more questions about equity, ethics, data access and ownership. All this will affect scholarship.

It is not possible to accurately predict the future scholars’ expectations. Yet, given what we know from Ph.D. students (Millennials) today, and what we know about Generation Z, we might start to consider what their expectations could be. A comparison of the two might help us out¹³:

QUALITY	MILLENNIALS	GENERATION Z
Realistic versus Idealistic	More optimistic.	More realistic: 77% expect to work harder than previous generations.
Independent versus Collaborative	More collaborative.	More independent: 69% would rather have their own workspace than share it with someone else.
Digital Natives versus Digital Pioneers	Saw the beginning and growth of social media, instant messaging, smartphones, search engines, and mobile devices.	Grew up with ubiquitous connectivity, highly curated global information, on-demand video, and 24/7 news cycles.
Private versus Public	Use social media to make their thoughts, opinions and more public.	More private. Chose Snapchat because of the time bound content that won't live online forever like a Tweet or Facebook posts.
Face-to-Face versus Digital-Only	Pioneered digital communications.	74% prefer to communicate face-to-face with colleagues.
On-Demand Learning vs Formally Educated	Question whether education was worth it or not.	Will pursue on-demand or just-in-time learning solutions, like how-to YouTube tutorials, or will seek employers that offer robust on-the-job and development training.
Role-Hopping vs Job-Hopping	Impatient with career stagnation and will move around to achieve it.	75% would be interested in having multiple roles within one place of employment.
Global Citizen vs Global Spectator	The first global generation – shared similar characteristics and values across borders and were able to view significant global events in real-time.	Interact with their global peers with greater fluidity than any other generation.

¹² <http://www.chronicle.com/article/What-Will-Doctoral-Education/234666> (accessed October 9, 2017).

¹³ <https://www.inc.com/ryan-jenkins/generation-z-vs-millennials-the-8-differences-you-.html> (accessed October 9, 2017).

Some general technology characteristics about Generation Z might be further helpful in our exploration of the future of scholars and digital scholarship.

- They process information faster than other generations thanks to apps like Snapchat and Vine.
- They are multi-taskers – as one article described it, in school, they create documents on their school computer, do research on their phone or tablet, take notes on a notepad, and finish in front of the TV with a laptop, while facetimeing a friend¹⁴.
- They have a significant digital footprint (92%) and they identify globally with their peers.
- They are addicted to their devices.

We should expect that future scholars start with these behaviors and the expectations associated with them. With this in mind, let's look at future scholarship in the context of:

- Idea generation.
- Research expression.
- Authoring and publishing.

5. IDEA GENERATION

I propose three possible scenarios. The scenarios build on what we know about digital innovations, the nature of digital scholarship, and specific data points on Millennials and Generation Z. They are hypotheses, and require further exploration before being proposed as probable. The three scenarios are:

1. Complex topics will be studied in multi-modal, multi-dimensional, immersive, smart and connected laboratories.
2. Interdisciplinary networks will increase with global interdependencies.
3. Human-machine relationships will create new dimensions of comprehension.

¹⁴ http://www.huffingtonpost.com/george-beall/8-key-differences-between_b_12814200.html (accessed October 10, 2017).

5.1. POSSIBLE SCENARIO 1. SMART AND CONNECTED LABORATORIES

During our lifetime, most scholars will be knowledge creators in some combination of multi-modal, multi-dimensional, immersive environments, where the lines become increasingly blurred between the physical, digital and biological. I call such environments smart and connected laboratories – somewhat building off the work by the National Science Foundation on smart and connected communities, cyberlearning, and human-machine interfaces.

The preponderance of sensors, devices, and yet –to-be invented connections has the potential to be very real, very soon. Scholars will increasingly use the confluence of sensor-enabled inanimate objects, human bodies, brains, the world and the universe, as their laboratories. All disciplines, with the exception perhaps of a humanist doing archival research using information that was never stored digitally, can be seen to work in such a laboratory. Augmented reality, artificial intelligence, and robotics can deepen, and expand the opportunities for research. No doubt political, financial and economic constraints will constrict it. Some examples point in this direction:

- Measuring earth's outgoing energy as a way to predict changes in Earth's climate¹⁵.
 - Faculty summits on AI with private-public partners such as Microsoft¹⁶ are common.
 - Augmented reality is now very real in education before and during university studies.

5.2. POSSIBLE SCENARIO 2. INTERDISCIPLINARY NETWORKS AND GLOBAL INTERDEPENDENCY

Scholarship will continue to gravitate towards global inclusivity as our existence becomes increasingly interdependent, which will contribute to interdisciplinary research growth, even the further expansion of research to include non-traditional scholars and communities.

Since 2013, Ithaka S&R has studied digital scholarship in Art History, Chemistry, Religious Studies and History. Their work confirms scholars

¹⁵ <https://www.nasa.gov/feature/goddard/2017/mission-success-ravan-cubesat-measures-earth-s-outgoing-energy> (accessed October 9, 2017).

¹⁶ <https://www.microsoft.com/en-us/research/blog/explore-advances-in-artificial-intelligenceand-much-more/> (accessed October 9, 2017).

expect to be even more collaborative in their work, and for research to be even more interdisciplinary. A study done in 2015 and published in *Nature*¹⁷ shows that research papers have increasingly cited work outside their own disciplines since the mid-1980's. Interdisciplinary publication by field was tracked as well with social studies of medicine the most interdisciplinary and nuclear and particle physics the least. And while the evidence shows that interdisciplinarity is not pervasive, it is trending upwards. Further evidence of interdisciplinary work includes institutional recognition of SciVal's collaboration and impact metric, as well as its academic-corporate collaboration and impact measure.

There will be economic pressure for collaborative and interdisciplinary research. Grant making and funding organizations expect more collaboration and interdisciplinary research to address complex global problems such as poverty, immigration, and health. And, community engagement in identifying, prioritizing, and implementing sustainable solutions is often a key requirement of funding.

We see a trend already underway.

- The 2016 article announcing confirmation of a prediction regarding gravitational waves in Einstein's theory of relativity listed more than 1000 co-authors¹⁸.
- The hunt for antibiotics with crowdsourcing support¹⁹.
- The UN 2030 Sustainable Development Goals focus on global, cross-cutting themes.

5.3. POSSIBLE SCENARIO 3. HUMAN-MACHINE RELATIONSHIPS AND NEW DIMENSIONS OF COMPREHENSION

This next generation of scholars will likely be working with data-driven algorithms, interacting with smart machines that are faster and more accurate than scholars could be on their own, yet require human judgement. Generation Z will be pioneers in robotics and artificial intelligence. Their digital skills and fluency will be well beyond basic universal literacy skills of office productivity software, image manipulation, cloud-based apps and content, and web content authoring tools; even beyond the skills that

¹⁷ <https://www.nature.com/news/interdisciplinary-research-by-the-numbers-1.18349> (accessed October 10, 2017).

¹⁸ https://www.nytimes.com/2016/02/12/science/ligo-gravitational-waves-black-holes-einstein.html?_r=0 (accessed October 9, 2017).

¹⁹ <https://www.microbe.net/2017/06/20/great-article-by-maryn-mckenna-on-the-hunt-for-new-antibiotics-w-crowdsourcing-help/> (accessed October 10, 2017).

are native to them: production of richer content, including video editing, audio creation and editing, animation, an understanding of computational device hardware, and programming. It will expand to virtual reality and augmented reality. With the changing context social skills related to digital citizenship may become even more focused on privacy and security.

On a very practical level, society is invested in increasing skills in new digital fields. It stands to follow that scholars will be too. The EU Donegal Digital pilot project is one example of many private-public partnerships to increase digital fluency skills for the near future. The pilot project announced in June this year is an example of digital fluency needs for the near future. The pilot will invest €10 million between 2018 and 2020 to give 5000-6000 students of all disciplines hands-on experience in fields such as cybersecurity, big data, quantum or artificial intelligence, that are highly demanded by companies and organizations²⁰. This is a small number of EU students, but a sign of changing skill-set needs.

This partnership between humans and machines is already underway and may lead to whole new fields of research questions. Some examples will illustrate the point:

- MIT recently announced that it has found a way to use robotics that allow scientists to study single neurons and to learn how single neurons interact with other cells to enable cognition, sensory perception, and other brain functions. They point out that researchers could also use it to learn more about how neural circuits are affected by brain disorders²¹.
- In a recent Tweet, Eric Schmidt from Google highlighted a breakthrough in DNA shared in YouTube. Simply by touching a chip to skin adds DNA that turns into vascular cells, neurons and other important material that makes it possible to treat disease²².
- Another example of human machine partnerships is Meta – the recently acquired AI search engine. Meta’s CEO states its purpose best: «Scientists lack the means to make sense of the vast amount of research being produced around the world. To speed up progress, researchers need to be able to learn from each other’s insights in real time»²³. Each day, more than 4,000 scientific papers are published in biomedicine

²⁰ <https://www.ernact.eu/NewsDetail.aspx?MediaNewsId=530> (accessed October 7, 2017).

²¹ <https://www.media.mit.edu/articles/robotic-system-monitors-specific-neurons/> (accessed October 7, 2017).

²² https://www.youtube.com/watch?time_continue=136&v=tMQ5iKj2tSo (accessed October 7, 2017).

²³ <http://meta.com> (accessed October 7, 2017).

alone. The AI recognizes authors and citations between papers in order to surface the most important research in over 26 million science research papers.

6. RESEARCH EXPRESSION

There is much discussion about the value of long form writing such as dissertations and monographs in the humanities, and multimedia in journal articles and papers in the sciences and social sciences. Let's not even get into wikis, blogs, microblogs, social media, videos, podcasts and data repositories. If scholars want a broader audience than their peers, they will continue to explore consumable forms in which to express it.

Nevertheless, people's information consumption is changing so dramatically from text to video, with increasing preference for interactivity through augmented reality, simulations, and virtual reality, that I firmly believe research expressions will change too. If we go back to our earlier conversation about Generation Z, it's hard to imagine that they will be satisfied with expressing their knowledge in anything other than multi-media and immersive expressions. As children they are mapping the topographic effects of climate²⁴. They are growing up in a time when robots are designed to complement or even independently explore Mars²⁵. And given this, and their preference for realism – they may prefer to express their research as actual prototypes rather than in a two dimensional format.

A few examples include:

- The American Panorama – a digital humanities project on forced migration²⁶.
- The Invention Coach – a way for Generation Z and next generations to learn about density²⁷.
- The fact that Europe held its 7th Immersive education summit this spring²⁸.

²⁴ <http://www.sandiegouniontribune.com/news/education/sd-se-bayside-steam-20161118-story.html> (accessed October 6, 2017).

²⁵ https://www.nasa.gov/mission_pages/mars/main/index.html (accessed October 9, 2017).

²⁶ <http://dsl.richmond.edu/panorama/> (accessed October 9, 2017).

²⁷ <http://circlcenter.org/the-invention-coach/> (accessed October 9, 2017).

²⁸ <http://immersiveducation.org/news/2017/03/14/immersive-italy-2017-and-7th-european-immersive-education-summit-announced> (accessed October 9, 2017).

7. AUTHORING AND PUBLISHING

I think it is safe to assume that these two acts –authoring, particularly collaborative authoring, and publishing– will become even more integrally intertwined. This is not to say that all authoring and publishing within or across a discipline will occur in a single interface; or that publication will occur instantaneously as an item is authored (although that may not be as farfetched as we think). Rather, I mean that collaborative authoring becomes more enriched leading to a product or products that can be expressed in a variety of forms, with releases possible at any point in time.

Imagine if these two ideas –collaborative authoring, and publishing– occurred more tightly together. The process might actually look a little bit like blockchain technology. Imagine:

A group of scholars agreed on standards for publishing. They assign a specific block of the research process, including a unique identifier, to a scholar or team of scholars in the chain, with the whole chain decipherable by AI. When the scholars confirm that their «research block» is ready to share, they invite other scholars to validate and approve it. Once the block is confirmed, others can build on it. If, a majority of the original research blockchain consider any piece of the chain to be invalid, and there is agreement that another research block is valid, a fork occurs in the chain and scholarship goes in another direction. But, the paths are never lost and the authoring and publishing link is completely intertwined.

Here are some examples of pioneer practices and platforms for authoring and dissemination. These examples show how scholars might author collaboratively, use enriched technologies such as linking, software programs and people, provide access to code, and executable figures, and embed multimedia (audio, video, 3D images, interactive images) – even author in immersive experiences.

- The Paper of the Future

In their article on The Paper of the Future, Alyssa Goodman and Josh Peek, share their future wish for science publishing. Through platforms such as Authorea, collaborative authoring, is focused on scholarly «papers» that become long-lasting rich records of scientific discourse, enriched with deep data and code linkages, interactive figures, audio, video, and commenting – during the authoring process²⁹.

²⁹ <https://www.authorea.com/users/23/articles/8762-the-paper-of-the-future> (accessed October 6, 2017).

- Press Forward³⁰

Press Forward is software used to curate, discuss, and share content online. It takes scholarship that is published directly online, focused on aggregation and curation. Evaluation, critical response, and validation happen in the open with multiple respondents, as opposed to closed review by anonymous peers. Value is identified based on the community creating and using the discourse.

- Open Science Framework³¹

The OSF is a tool that connects the scholar with the entire scholarly communications lifecycle.

8. DIGITAL FLUENCY IN TOMORROW'S INFORMATION ENVIRONMENT

A scholar's mission is to discover and share new knowledge. That has not changed – nor will it likely change. In a world increasingly disrupted by technological innovations, how they accomplish their mission will change. Digital fluency will be required.

For many scholars, digital fluency will require competencies beyond multimedia, and beyond small and big data. This paper highlights a few needed competencies:

- Critical thinking on complex topics.
- Strong communication skills across disciplines, among generations, with external partners, including community members.
- Ability to design research protocols with new technology capabilities.
- Degrees of mastery of Artificial Intelligence, robotics, sensor technologies, systems of connected devices.
- Design, even development, and ability to use research authoring and publishing platforms.
- Understanding of ethics, intellectual rights, and contracts.

And we will be there with them.

Like scholars, our mission has not changed. We are collaborative partners who understand, advise, and create opportunities for everyone to benefit from knowledge from the past, present and future. We do this by:

³⁰ <http://pressforward.org> (accessed October 6, 2017).

³¹ <https://osf.io> (accessed October 6, 2017).

- Actively participating in the full scholarship lifecycle of scholarly production and authoring, research assessment and credit, infrastructure, education and professionalization, and research funding and support.
 - Creating the best information environment, locally and globally, in which knowledge can be created.
 - Participating in developing and providing the best methods for knowledge dissemination.
 - Creating and managing the best methods for curating, stewarding, and preserving knowledge assets from the past, the present, and for the future.
- Assisting with learning how to navigate the information environment.
- And, being advocates for an informed society and information rights so that everyone is aware of, has access to, and can use the information.

How we will do our work will change. I will share three considerations on our future roles and responsibilities.

1. Collaborative Partner in a World of Labs.
2. Collective Curation of the World's Knowledge.
3. Trusted Coach and Advocate.

9. COLLABORATIVE PARTNER IN A WORLD OF LABS

With the world and the universe as the scholars laboratory, digital scholarship labs, seem to me, the beginnings of a microcosm of a far bigger research information environment – one in which research is conducted in and outside of institutions, across disciplines, across cities, with connections possible along many dimensions, through private-public partnerships, from the desktop as well as through very powerful networks.

There will be digital scholarship labs in libraries, and universities, and shared labs across institutions, governments, and corporations. In universities and some public and national libraries, digital scholarship labs support many forms of digital scholarship, and will now support robotics, artificial intelligence, simulations, virtual reality, smart machines. For instance, the University of Michigan recently announced a digital scholarship lab that will feature a 360-degree immersive visualization room that will accommodate up to 20 students along with a virtual reality room for experimentation

with VR headsets³². If this were the only such lab that would not be news. Several other US universities already have or are planning to create similar cross disciplinary labs – and there is significant funding for libraries in the US to do so. It is becoming the norm.

However, library-based digital scholarship labs are only one piece of a larger network of scholars' labs. The EU Science Hub is an example of a European-wide effort to create science labs that make tools and data available to the public or select audiences. Other privately funded initiatives like the Human Cell Atlas³³, an international project to map all cell types and states in the human body and thereby contribute to disease management, exist as well. And given the expense of such investments, private-public partnerships are to be expected.

As digital labs proliferate, there is an opportunity for librarians and other information professionals to contribute to their development and iteration. This is an active role – one that requires deep knowledge of emerging and future technologies and their implication for scholars and information itself. And let's not forget the implications for human beings and our existence. By taking on a leadership role as curator, steward and even disseminator, we can use the innovations to advance our mission on behalf of scholars and society. This is a local opportunity and a global opportunity. We can work in our institutions and together as a community.

This is so critical, I cannot overstate it. By participating in lab development and iteration, i.e. at the beginning of idea generation, we can have a substantive impact on the future of scholarship and our world.

10. COLLECTIVE CURATION OF THE WORLD'S KNOWLEDGE

Over the past couple of years I have co-chaired a working group in the Digital Culture Program at the Social Science Research Council, on the curation of knowledge under digital conditions. As a result of focus groups with academic leaders, scholars, publishers, librarians, journalists, and students, we identified six conditions in which tomorrow's scholars will work, and in which we must ensure they have the appropriate information environment and levels of fluency to do their best work:

- Complexity – complexity refers to a dynamic networks of interactions with known as well as unknown and unpredictable responses. Research

³² <http://msutoday.msu.edu/news/2017/state-of-the-art-digital-scholarship-lab-coming-to-msu/> (accessed October 6, 2017).

³³ <http://jamanetwork.com/learning/audio-player/14627747> (accessed October 6, 2017).

stewardship and the way in which we manage and share information seem to be in a continual state of flux. This is compounded by the objects morphing form and format and the rapidly evolving digital skillsets and competencies required for their production and sensemaking.

- Scaling – the use and creation of data on scales of minutiae and the universe; the ability to zoom in on detail while zooming out to comprehend otherwise incomprehensible patterns; as well as the stewardship of data at local and in global networks.
- Authority – recognition of the need to maintain peer review, research reproducibility, and academic credentials while understanding shifts in perceptions of authoritativeness, particularly among lay consumers of scientific work.
- Sharing – we have already covered this extensively with collaborative authoring, and Ayers generative scholarship. Crowdsourcing, open access, and advances in computational power, distributed networks, and mobile devices means sharing is possible almost simultaneously, anywhere, anytime, on any device.
- Erasure – there are at least three forms of erasure 1) erasure of data that gets lost because we simply choose not to preserve it; 2) erasure through the ways our work reflects cultural or historical biases and omissions; and 3) erasure through ignorance i.e. not understanding how new research methods contribute to gaps in knowledge.
- Persistence – Persistence speaks to the tension in digital culture to vacillate between temporary states and permanence. As speeds of information creation and flow increase this will become an even more challenging condition.

We have the opportunity and responsibility to ensure the world's knowledge is curated in conditions that we can influence. It will require us to investigate, along with others, how best to do so with an information explosion unlike any we have seen in our lifetimes – and many private and public institutions seeking the benefits. Partnerships will be key as we lead and participate in a collective, complex ecosystem. We will be nodes in a perpetual flow of information –and a fluid governance process. There are obvious benefits of collective intelligence– particularly that it is realistic in this networked world. There are many examples of collective intelligence initiatives using existing technologies already, including crowdsourcing. For instance, the Million Image Database at Oxford's Institute for Digital Archaeology³⁴, and iNaturalist. Our ability to understand the dynamics of curation under these conditions will be essential.

³⁴ <http://www.millionimage.org.uk> (accessed October 9, 2017).

II. TRUSTED COACH AND ADVOCATE

We have left an era primarily experienced through the physical properties of our world and its digital expression. The new era is experienced through the immersive conditions of the physical, digital, and biological –one that extends into new forms of expression. Generation Z may be very comfortable with the new experiences– others will need to cross a gap. We will need skills in artificial intelligence, human-machine dynamics, sensor-based data systems, and an understanding of their implications to local and global systems. While some skills can be identified now, it is not possible to predict the next set of needed skills. All people will, at some time, seek a resource they trust to help them learn and to make sense of a complex information environment. Let's be that source of knowledge, and if it is not our expertise, the source for worthy referrals.

We are in an era where knowing how to learn is a most important skill. To remain a trusted coach and advocate we will need to learn new digital scholarship methods – and learn how best to coach others in their adoption. This means coaching on platform use, collaborative authorship and publishing, understanding discipline methodologies, and translating for interdisciplinary work.

Several institutions have given significant thought to what those scholarship skills need to be. For instance,

- The American Association of Colleges and Universities agreed to set of learning outcomes for the 21st century³⁵.
- A study in 2014 sought to define the digital social sciences³⁶. In this field there are several forms of digital scholarship – computationally intensive research (similar to the digital humanities) such as social network analysis, complexity modeling, and social simulations; digital social science, defined as «the application of a new generation of distributed, digital technologies to social science research problems», digital cultural heritage, and internet studies.
- The Association of Research Libraries hosts us National Digital Stewardship residents, and runs digital scholarship institutes for librarians

And let's not forget, that in this new era there are and will be many debates about ethics, privacy, security, digital rights, and access. Principles will surely be tested and we will need to be voices for reason and

³⁵ <https://www.aacu.org/leap/essential-learning-outcomes> (accessed October 9, 2017).

³⁶ <http://acrl.ala.org/dh/2014/04/09/defining-digital-social-sciences/> (accessed October 9, 2017).

participants with activists and scholars in local and global adoption of rights. Our role will need to be a proactive and engaged leader; partnering with other experts to create an even better future.

12. IN CONCLUSION

And so, here we are, scholars, thought leaders, leading information practitioners from all across Spain, Europe, Latin America and the United States. It is a challenging time, yet a tremendous opportunity to be in this fourth technological revolution – with so much to do to be exceptional collaborative partners, curators and stewards of scholars work from the past, the present, and for the future. I hope the text provokes about:

- The nature of digital scholarship in our lifetime.
- Scholars and digital fluency in our lifetime.
- What this means for tomorrow’s information environment, specifically our role.