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The Future of Learning Technology: 10 Key Tools and Methods

Insight Papers

The Future of Higher Education

A Contact North | Contact Nord Series

In this issue

Educators and students have taken a massive leap forward in the pivot to remote learning. But what will the new normal look like?

From the web of data and virtualization to a renewed emphasis on personal privacy and security, the educational technology tools and methods that are already in the works will be part of our everyday lives by 2030.

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About Contact North | Contact Nord

As Ontario's community-based bilingual distance education and training network, Contact North | Contact Nord helps underserved residents in 1,300+ small, rural, remote, Indigenous and Francophone communities access education and training without leaving their communities.

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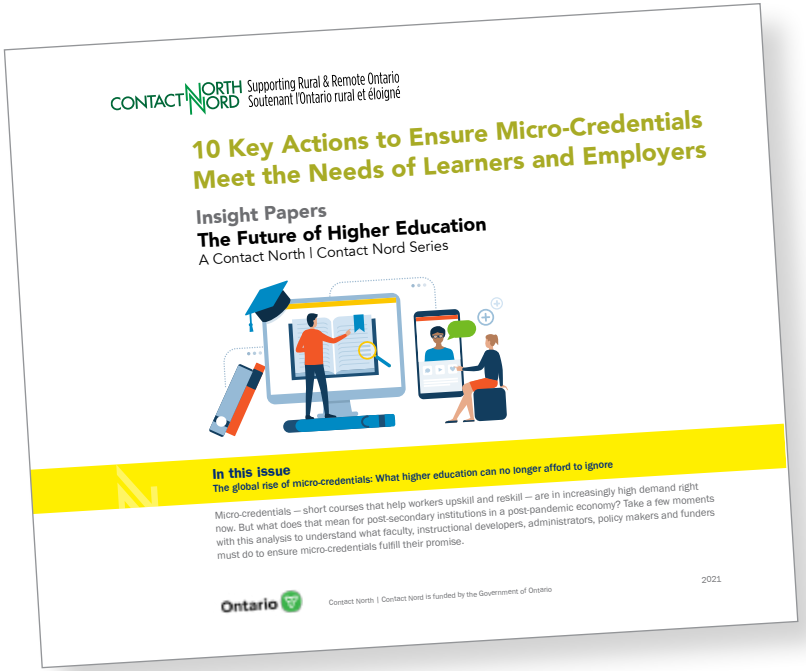
About Insight Papers

Written with faculty and instructors in mind, Contact North | Contact Nord's series on the future of higher education is designed to explore current trends, highlight the risks and opportunities, and stimulate debate about higher education in a post-pandemic world.



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The Future of Learning Technology: 10 Key Tools and Methods

At the beginning of the COVID-19 pandemic, the education system in Canada and around the world received an unexpected shock as schools, colleges and universities closed and people began working and learning from home. It showed how ill-prepared many faculty and instructors were to work online, and yet at the same time, how well-prepared they were to pivot to remote learning. Some institutions made the transition in as little as two weeks; others took much longer.

The pivot to remote learning was in many ways flawed. Some said it did not even qualify as online learning. But as institutions adapted, educators learned from the previous decades of online learning. Investments in videoconferencing technologies helped them stay in close contact with students, while learning management systems and electronic resources were adapted to support access from home.

The pivot to remote learning also exposed issues of equity and access. At-risk students began to fade from view. Some students, especially rural and Indigenous students, did not have Internet access. Others found it difficult to learn remotely. Most found videoconferencing sessions exhausting. Observers began to warn of a potential learning loss.

As faculty, instructors, students, administrators, policy-makers and funders, we learned a lot. But what can we expect in the future?

10 Major Tools that will be Mainstream by 2030

Almost all the 10 educational technology tools and methods outlined below are already in development to some extent, posing questions that institutional administrations need to consider.

It is difficult to be precise with timelines in longer-term technology deployment. However, in education, those that are in some sort of pilot phase today will likely begin to be more widely adopted within two to three years and be mainstream by 2030.

1. Web of Data

The most significant long-term transformation in knowledge and learning is the pedagogical transition from narrative to data.

It's like relying less on stories of exploration and much more on charts and maps. It represents a transition from linear forms of knowledge transmission toward distributed representations such as models, dashboards and simulations. Where in the past we created a library, today we are creating a web of data.

Data is more flexible and more useful. We can draw connections in multiple dimensions between different pieces of information. We can insert one piece of data into another piece of data, such as a template. Our perspective shifts from a linear organization to something more

complex. We begin to see patterns in the data, and to realize that events are shaped by whole ecosystems rather than simple cause and effect.

The way we learn in such an information landscape is going to change as well. It is not the same as simply reading books, listening to instruction and remembering facts. While we can teach that way, and while research shows that it works, the result is that students are left with only a superficial understanding of a subject when what they need is to be able to appreciate its depth and complexity.

Courses need to be designed as changing and dynamic environments. The course curriculum becomes the web of data informing this environment, ideally connected to real-world data and authentic problems. Students use their own tools and bring their own background knowledge. They interact not only with each other but with the wider community, working cooperatively to respond to challenges or tasks.

Learning institutions need to develop a strategy of offering support to these environments and the students in them. They contribute to the web of data by creating open and accessible resources that can be used, linked and manipulated as needed. They create access to the tools students need to access, manage, share and work with data — tools that range from Internet access to simulated environments to sensors and robotics. And they need to plan to use feedback and analytics, and to access support provided by a range of professional services.

2. Virtualization

Today we think of a computer as a specific device, like a box on our desktop or a mobile phone in our hand, running a specific operating system such as Windows or iOS, with all its programs and data collected in one place. **Virtualization removes the computing from the device** so you can have as many "computers" as you want. These are called "images" or "containers." Once you create an image, you can run it wherever you want and share it with whomever you want.

Virtualization began with applications such as VMWare and Parallels and progressed through a range of increasingly sophisticated computing containers created using programs like Vagrant and Docker. Today, we access them using cloud services like Amazon Web Services (AWS), Google Cloud or Microsoft Azure.

These new resources allow us to redefine what we mean by "textbooks" and even "learning objects." Students can easily access a complex computing environment, pre-configured and loaded with data from the web of data, and use applications for manipulation, visualization and creativity. With automated creation and deployment of cloud containers, entire courses can be created in a box and then accessed when and where needed. They are multi-user, supporting conferencing, collaboration and co-creation.

Learning environments are versions of the actual tools employed professionally, perhaps with additional instruction provided, sample data sets employed and supplementary tutorial support enabled. Developers "spin up" to a cloud environment, create a set of base

boxes with core tools, and begin piloting and evaluating these new environments in specific professional applications such as space or health care. It is important to connect and keep up to date with the environments actually being used by practitioners in these fields.

Students edit and create new tools to create text, music and art. They can directly experience the relation between algorithm and outcome, or between mathematics and music, for example. Learning institutions manage online course environments that use cloud applications to make the tools they need available to learners.

3. Graph

A graph is a network of things that are connected together. Different types of graphs can be created by connecting different types of things; a social graph, for example, connects people. In formal graph theory, the things that are connected are called nodes, and the connections themselves are called edges.

Graphs are important because they represent knowledge, not only as collections of facts and statements, but also as patterns of connectivity. For example, a graph of scientific knowledge shows much more clearly how different disciplines relate to each other. Meanwhile, a graph representing a viral infection can be used to identify the spread of a disease from one person to the other.

Graph theory appears everywhere in cutting-edge technology. For example, repositories such as GitHub and digital currencies including Bitcoin and Ethereum are based on a combination of encryption and directed acyclic graphs (DAG). Modern artificial intelligence, such as deep learning, is based on artificial neural networks.

The web of data invites us to think of learning resources as graphs, and to see that all events are complex events and all disciplines are complex disciplines. By mapping the graph of a discipline researchers can obtain a “map” of the field, helping them instantly perceive trends and relations of ideas. This gives students multiple entry points into the study of that discipline.

A strategic application of graph theory in institutions proceeds in two dimensions:

- First, by mapping existing graphs in a domain of knowledge, including linkages between staff members to identify key personnel, points of connection in curricula to identify potentials for collaboration, and clustering and association in the student body to identify outliers and those who may be at risk.
- Second, by addressing how connections are defined and grown in an institution; for example, by devising processes that discourage the formation of silos or generate inter-institutional connections.

4. Distributed Resources

Because of such technologies as Digital Object Identifier (DOI) and content distribution networks (CDN), the physical location of a resource matters less and less. But data is put behind paywalls, locked in social networks and hidden in content silos. Meanwhile, personal data extracted by these systems is commodified and monetized.

A mechanism known as Web3 is, to a large degree, a reaction against this. **Web3 enables the same piece of content to be in many places at the same time**, securing the same benefit as content distribution networks but, at the same time, making it much more difficult to enclose behind proprietary middleware.

The method employed is called "content addressing." It essentially involves the extraction of a string of characters, or "hash," by encrypting the resource. Each hash is unique, so services can request contents according to their hash address rather than their location. Today, distributed web content protocols such as Dat and the interplanetary file system (IPFS) are running as prototypes using encryption, hashing and blockchain to create a record of ownership.

Some recent examples include Non-Fungible Tokens (NFT) that can be bought and sold, distributed applications (dApps), subscriptions and lists, contract networks, and even Distributed Autonomous Organizations (DAO).

Education institutions can prepare by developing the relevant competencies in-house and preparing core assets for distribution in decentralized networks. Some institutions are doing both by creating digital badges to recognize student achievement, and then recording them in a blockchain.

Instructional designers and information services can also begin to investigate the potential of building or joining distributed content networks to create a common pool of open educational resources. In the longer term, institutions want to **look at emerging pedagogies based on the creation, use and manipulation of decentralized resource networks.**

5. Consensus

The fundamental challenge to community is to make decisions on matters affecting everybody while leaving to individuals, companies and institutions those matters not collectively managed. In a democracy, many of these decisions are made through some form of majority rule, although authority is often delegated to a hierarchy or management structure.

Recent years have seen **the emergence of alternative models built around principles of protocols and consensus**, as seen in the development and governance of the Internet, for example. In much the same way, the web of data creates a distributed graph of resources — or in the same way the Internet creates a distributed constellation of websites, it could be said that management and governance are trending toward a distributed model of decision-making.

But what are the conditions for consensus? It is about more than voting and having power. It requires a basis in "sources of truth," and new consensus algorithms such as Paxos are based on the creation and manipulation of digital objects that everybody can independently inspect and confirm are true. This enables different interests to interact without requiring authority or trust, defining community not as agreement or sameness but by consensus about facts, algorithms and models.

A key challenge today is to define these sources of truth. Governments and institutions are developing and experimenting with a wide variety of distributed technologies to learn how to build and manage consensus-based community. It is important to learn not only how consensus is created but also how it is undermined. It is important for education institutions to be a part of this discussion.

It is difficult to imagine defining truth by consensus rather than defining truth by authority. So, defining community as consensus is probably best viewed as a generational change. The adoption of **new learning technologies can and should include room for new forms of community** and promote new literacies enabling students to thrive in them.

6. Digital Identity

In the field of learning technology, there is a tendency to look at identity relatively narrowly, asking how we know who someone is, what we say about ourselves on the Internet and how we can be safe and secure. But in the future, our attention will shift from how we prove we are who we are to how we define ourselves online.

Soon, simple passwords will be replaced and identity theft will be a thing of the past. New secure identities backed by decentralized identifiers (DID) and verifiable credentials will become commonplace. You already carry them in your chip card or Google Pay. But new, robust online identity raises a host of new questions. Who are we? What does our digital identity look like? How are we seen in the world? These are questions that already resonate today.

For example, **consider the concept of the "identity graph"** used by advertisers to construct individual profiles for marketing and persuasion. Data is gathered and activity is tracked across hundreds of websites (not always with the person's knowledge and consent). This raises numerous ethical issues related to the nature of the identity graph, how it is created and how it is applied.

There are benefits to **helping and encouraging learners to create and manage their own identity graphs.** We can think of them as a much-

augmented digital wallet, enabling not only online commerce but also government, health care, educational records, personal portfolios and work experiences. Given permission to access and use these, institutions can replace demographics with a rich tapestry of data and relations.

In this new data-rich world, we are the content. We are the thread that runs through an otherwise disconnected set of data. Knowledge about ourselves creates an underlying fabric against which the value and relevance of everything else will be measured.

It is important for education institutions to consider how online identity is created and managed. They play an important role in supporting and teaching about digital identity and need to share clear and ethical policies governing the ownership, management and application of identity data.

7. Creative Experiences

Virtual or augmented reality simulations offer the potential for multi-sensory immersive experience. Artificial intelligence offers the potential for complex and challenging interactivity. And communications technologies offer the potential for community-based or collaborative experiences. Yet **so much of education continues to rely on indirect methods** that depend on knowledge transfer — reading, lectures, videos — rather than hands-on practice and knowledge creation.

This is about to change. Instead of delivering content, a teacher will model and demonstrate successful practice, and learners will seek to emulate and build on what they see and experience. **In this new model, the creation of the content becomes a part of the content itself.**

Artists made working openly a part of the act. Deadmau5, for example, shows how electronic music is produced. Online platforms combine tools to watch with tools to create. TikTok, for example, hosts viral videos but also offers a range of tools to help users create their own. In games and activities on live-streaming platforms such as Twitch and streaming games like Fortnite, **players become spectators, and back again, over and over**.

For education institutions, the key starting point is to identify ways to combine content and creativity. Institutions should look at, for example, tools like Jupyter Notebooks that **combine data and code in**

a document allowing readers to manipulate software and real-time data to model real-world scenarios. And they should help students use applications like YouTube or Open Broadcaster Software to create and share real-time videos of their experiments.

Implementing a blend of content and creativity in remote teaching and learning means exploring how online tools can be used to work (and play) collaboratively. The **dialogue and interactivity that takes place during the creation sets the work into context** and enables the person to see it as a process rather than an artifact. Rather than thinking of creativity as an adjunct to learning, it may be more useful to think of it as "learning while creating things."

8. Recognition

Today, institutions are focused on the integrity of assessments, identifying plagiarism using TurnItIn and doing online invigilation with Proctorio, for example. But **the future belongs to automated assessment tools** already used to grade natural language content such as tests and essays.

And although they may score more consistently than human instructors, they are criticized because they are too easy to fool and don't really understand the content they are evaluating. They are criticized for invading student's privacy, and for bias and misrepresentation. **Actual authentic tasks designed or contributed by humans may be needed to balance the possibility of biased algorithms.**

What happens with automated assessment, though, is that anyone can assess performance based on whatever criteria they deem important. There are concerns about the wider implications of unrestrained performance and compliance assessment, but the benefits are too obvious to ignore.

Therefore, **institutions need to plan for a future in which learning is recognized not by degrees or diplomas but by job offers.** Software that draws directly from a person's online profile to select applicants for jobs and work is already in use by recruitment and employment agencies. Today these are unreliable and superficial. But with trustworthy data from distributed networks, they will be able to accurately determine the skills and potential of every individual.

Institutions may need to reconsider how to define learning objectives that do not map to specific outcomes or even to specific jobs, but instead contribute to a desirable profile that satisfies a wide range of currently undefined performance criteria. Individuals need to be able to design their own digital identity and portfolio for public assessment from multiple points of view, based on different employer needs.

9. Agency

What we learn depends on why we learn, and the idea of agency is to enable this to be shaped by the learner. We can think of this as the attractor as opposed to a driver. For example, one commonly cited set of attractors is Maslow's hierarchy, which suggests we first focus on material needs and then on social and spiritual needs.

Agency is impacted by technology. Each of the major developments in the Internet — from the client-server model to platform-based interoperability to web3-based consensus networks — was accompanied by a shift in agency, a shift in the relative standing of the individual with respect to community, institutions and governments, for better or worse.

Individual agency is in turn what consensus-based decentralized communities are designed to augment, and we can trace elements of agency through each of the systems and technologies we have discussed above, from web of data to recognition. But **as content, media and technology become sophisticated and more autonomous, how do we bind these to learners' economic, cultural and ethical aspirations?**

In a theory of agency, these priorities are established by individual conditions and character, and may include elements such as security, identity, voice and opportunity. **Success therefore needs to be evaluated according to these wider metrics**, defined not only in terms of employment opportunities, competencies, skills and expertise, but by agency. Can the learner learn, think and do for themselves in a rapidly changing and complex environment?

Institutional policy and, in particular, institutional learning technology choices should be linked to this characterization. Historically, institutions focused on developing the tools and capacities needed to support social, political and economic development. In the future, it will be

equally important that **education institutions emphasize and promote individual agency.**

10. Infrastructure

Recent world events such as the pandemic, combined with the explosion of new technologies, led individuals and societies to rethink what they value in their lives and how their work and learning should be structured. The outcome of this process is a reorganization of social infrastructure to fit these new priorities.

For example, **there is a renewed emphasis on personal privacy and security** in digital networks and services. In some places, this resulted

in legislative change, such as the European General Data Protection Regulation (GDPR), while elsewhere this desire is reflected in encrypted messaging tools and zero-knowledge proofs (ZPF) that allow someone to demonstrate they have credit or credentials without displaying their personal information.

There is also a renewed emphasis on resilience. The recent pandemic made clear the gaps in our social fabric, and especially the need for greater access to digital services in remote and rural regions, for low-income and working poor, for families with children and for the elderly and disabled. One solution rarely serves all, and these digital technologies need to support equitable, accessible, inclusive tools and services.

The pandemic also revealed **the greater need for individual capacity**, including improved literacy that encompasses the new forms of knowledge and exchange described in this Insight Paper. People need to learn how to perceive and comprehend rather than to decode and store. They need to learn and practise in environments that are interactive, immersive and engaging, environments that teach them to see, to recognize patterns and trends, and to respond with creativity and innovation. **Success is measured not in terms of what the learner remembers but in terms of what they do.**

Therefore, new technologies must be designed to meet people where they are, whether that's at home, the community centre, school or the workplace. They must be designed to support people no matter who they are, which not only suggests customized and personalized technologies, but also that a range of business models are needed to ensure sustainability while providing broad coverage.

A technological environment for the future

By the end of the decade, online learning will look much less like an online classroom and much more like an online workplace. In some cases, it might actually be the online workplace. Because so much of our work moved online, spurred in large part by the pandemic, online learning must follow. And for work that remains offline, online learning must provide much more practical experience in the form of virtual reality and simulations. The next 10 years will be a time to think about how curricula and learning design can make the shift from telling students about the world to showing them how to learn.

The nature of work will change as well. It is beyond the scope of this Insight Paper to describe the impact of, say, artificial intelligence on society in what is sometimes being called the fourth industrial revolution. But the need to be able to work within a world of data and virtualization creates the need for education systems to think about how students can adapt and learn and train our machines of the future.

Finally, these rapidly advancing technologies, as always, create a challenge for a just and equitable society. Students in all communities must be able to access the tools and resources they need to work with each other, with machines and with data. These areas that define the technological environment of the future also, in many ways define the skill sets everyone will need to ensure they can participate in, and enjoy the benefits of, an advanced information-age society.