NMC Horizon Project

NMC Technology Outlook

Cooperative Extension 2016-2021

NMC Technology Outlook for Cooperative Extension 2016-2021

A Horizon Project Sector Report

2016 NMC Technology Outlook for Cooperative Extension
A Horizon Project Sector Report

is a collaboration between

The New Media Consortium,
eXtension Foundation, and
ECOP Innovation Task Force

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Executive Summary

The *NMC Technology Outlook for Cooperative Extension 2016-2021: A Horizon Project Sector Report* reflects a collaborative research effort between the New Media Consortium (NMC), the eXtension Foundation, and the Innovation Task Force of the Extension Committee on Organization and Policy (ECOP), the representative governing body of Cooperative Extension nationwide, to inform Cooperative Extension leaders and decision-makers about significant developments in technologies supporting innovation and learning across the field. Cooperative Extension is a unique network that links local and campus-based Extension professionals from land-grant universities—along with federal, state and local partners — to residents of more than 3,000 counties/parishes in all 50 states, the District of Columbia, and U.S. territories. We translate science into formats that people use to improve their lives and/or livelihoods.

All of the research underpinning the report makes use of the NMC's Delphi-based process for bringing groups of experts to a consensus viewpoint. The same process underlies the well-known *NMC Horizon Report* series, which is the most visible product of an ongoing research effort begun 15 years ago to systematically identify and describe emerging technologies likely to have a large impact on education around the globe.

The *NMC Technology Outlook for Cooperative Extension 2016-2021* was produced to explore emerging technologies and forecast their potential impact expressly in Cooperative Extension programs. In the effort that took place from April through July 2016, an esteemed panel of experts was asked to consider hundreds of relevant articles, blog posts, research, and project examples as part of the preparation that ultimately pinpointed the most notable emerging technology topics, trends, and challenges for Cooperative Extension programs over the next five years.

Known as the 2016 Horizon Project Cooperative Extension Expert Panel, that group of thought leaders consists of knowledgeable individuals, all highly regarded in their fields. Collectively the panel represents a range of diverse perspectives across the Cooperative Extension sector. The project has been conducted under an open data philosophy, and all the interim projects, secondary research, discussions, and ranking instrumentation can be viewed at extension.wiki.nmc.org. The precise research methodology employed in producing the report is detailed in a special section found at the end of this report.

The expert panel identified 9 key trends, 9 significant challenges, and 12 important developments in educational technology. The 12 developments in technology are profiled, each on a single page that describes and defines a technology ranked as very important for Cooperative Extension programs over the next year, two to three years, or four to five years. Every page opens with a carefully crafted definition of the highlighted technology, outlines its educational relevance, points to several real-life examples of its current use, and ends with a short list of additional readings for those who wish to learn more.

Preceding those discussions are sections that detail the expert panel's top ranked trends and challenges, and frame them into categories that illuminate why they are seen as highly influential factors in the adoption of technology in Cooperative Extension programs over the next five years.

The three key sections of this report constitute a reference and straightforward technology planning guide for Cooperative Extension directors and administrators, educators, agents, faculty, staff, campus leaders, policymakers, and technologists. It is our hope that this research will help to inform the choices that institutions are making about technology to improve, support, or extend teaching, learning, and creative inquiry in Cooperative Extension programs. Educators and administrators worldwide look to the NMC Horizon Project and both its global and regional reports as key strategic technology planning references, and it is for that purpose that the *NMC Technology Outlook for Cooperative Extension 2016-2021* is presented.

Introduction

The NMC Horizon Project and the 2016 Cooperative Extension Expert Panel recognize that technology adoption in Cooperative Extension programs is accelerated by trends in policy, leadership, and practice. Therefore, key trends frame the discussion of technology use in Cooperative Extension programs. Similarly, a number of challenges are impeding the proliferation of digital tools, and the panel has identified a set of significant challenges that distinctly reflects the current drivers and obstacles facing Cooperative Extension programs over the coming five years. The top three trends and challenges from those longer lists are included in the related tables in this summary, and are organized by categories described in the next sections of this report.

While Cooperative Extension is part of the nation's Land-Grant University system, it is our observation that its programs are more similar to public-facing, non-formal teaching and learning sectors summarized in other Horizon Reports than the formal higher education sector Horizon Reports. As Table 1 below illustrates, the choices of the Cooperative Extension experts overlap in interesting ways with those who contributed to the *NMC Horizon Report > 2016 Museum Edition*, which looked at technology uptake from a museum perspective, and the *NMC Horizon Report > 2015 Library Edition*, which provides perspective from the library perspective — altogether a group of 153 acknowledged experts.

Table 1: Top-Ranked Trends Across Three NMC Horizon Research Projects

NMC Horizon Report 2016 Museum Edition	2016 Technology Outlook for Cooperative Extension	NMC Horizon Report 2015 Library Edition
	Long-Term Trend	
Cross-institution Collaboration	Emergence of New Audiences	Increasing Accessibility of Research Content
	Mid-Term Trend	
Data Analytics for Museum Operations	Growing Focus on Measuring Learning	Increasing Focus on Research Data Management
	Short-Term Trend	
Mobile Content and Delivery	Cross-institution Collaboration	Mobile Content and Delivery

The Cooperative Extension panel's highest ranked trends overlap with the museum panel's selections in one area — the importance of cross-institution collaboration. True to its name, Cooperative Extension has always been a hub to share quality research and Extension practices between institutions. What is new is the greater availability of technological tools to do so. Support behind technology-enabled teaching and learning has reinforced the trend toward open communities and consortia, as leaders recognize collective action as a sustainable method of supporting upgrades in technological infrastructure and IT services.[1]

Extension Reconsidered engaged Cooperative Extension partners from 13 states in pursuing partnerships between Extension and the arts, humanities, and design fields. Their work has continued into several ongoing collaborative initiatives that connect university students with Extension faculty and educators in creative projects that merge multimedia creation, such as sound capture, acting and directing, and video documentation with the local natural environment.[2]

Museum, library, and Cooperative Extension panels are all in agreement that data is increasingly informing how their institutions manage and evaluate the work they do. The growing focus on measuring learning describes a renewed interest in assessment and the wide variety of methods and tools that can monitor and analyze large amounts of data to help education professionals evaluate, measure, and document the learning progress, skill acquisition, or educational needs of stakeholders. Instructors at institutions that are premium members of eXtension can gain access to learning analytics through the Intelliboard service which works with the eXtension Campus Moodle learning management system as well as local Moodle instances.[3]

The 2016 Cooperative Extension panel also surfaced an entirely new trend for this report — the emergence of new audiences. Advancements in technology, such as emerging translation tools, are assisting field agents in connecting with non-native English speakers, especially in the rural southwest.[4] While rural audiences are key recipients of Extension services, engaging with audiences in urban corridors is seen as another opportunity for growth. To help connect urban dwellers with farm life, North Carolina State University has created a John Deere Model 1650 combine simulator, to familiarize users with the process of harvesting crops.[5]

NMC Horizon Project panels in general have agreed that trends like these are clear drivers of technology adoption; the 2016 Cooperative Extension panel especially saw such a linkage. At the same time, these panels of experts also agree that technology adoption is often hindered by both local and systemic challenges, which are grounded in everyday realities that make it difficult to learn about, much less adopt, new tools and approaches.

Table 2: Top-Ranked Challenges Across Three NMC Horizon Research Projects

NMC Horizon Report 2016 Museum Edition	2016 Technology Outlook for Cooperative Extension	NMC Horizon Report 2015 Library Edition
	Solvable Challenge	
Improving Digital Literacy	Embracing Change as a Constant	Improving Digital Literacy
	Difficult Challenge	
Measuring the Impact of New Technologies	Measuring the Impact of New Technologies	Rethinking the Roles and Skills of Librarians
	Wicked Challenge	
Managing Knowledge Obsolescence	Managing Knowledge Obsolescence	Managing Knowledge Obsolescence

As noted in Table 2, above, all three expert panels agreed that managing knowledge obsolescence is a wicked challenge, and will rely on effective and ongoing professional development to solve. Technology-enabled trends, such as user-created content, is exploding, giving rise to information, ideas, and opinions on all sorts of interesting topics, but following even some of the hundreds of available authorities means sifting through a mountain of information on a weekly or daily basis.[6] For example, as social media changes the way educators and agents communicate with each other and their stakeholders, it is important to stay current with trends in this form of communication.

The EdTech Learning Network[7] is one peer and expert resource of the Cooperative Extension System keeping Extension professionals on the leading edge of new technologies practices. The eXtension Innovation Lab[8] fosters innovation by incubating and testing new models and techniques and fostering the adoption of successful results with innovation fellows, projects and institutional teams. The professional associations affiliated with the Joint Council of Extension Professionals (JCEP) also incorporate technology-enabled trends in their professional development offerings.[9] The National Extension Technology Conference is one such professional development option available to Cooperative Extension professionals to help them keep pace with rapid advancements in technology.[10]

Both the 2016 Museum and Cooperative Extension panels indicated that measuring the impact of new technologies is a difficult challenge. While many organizations are astute at assessing their traditional programs, they have yet to cultivate standard protocols for measuring the success of the technologies they deploy. Unfortunately, there are not always concrete precedents for the use of new technologies in the informal learning sector, and organizations that are early adopters often gamble when trying them. The American Evaluation Association's Extension Education Evaluation Topical Interest Group is working to improve evaluation practice and methods through professional development.[11]

Encouraging Cooperative Extension professionals and stakeholders to embrace the mindful use of new technologies is considered the most solvable challenge by the 2016 Cooperative Extension Expert Panel. Technology has transformed the entertainment and publishing industries, yet educational institutions have been slow to leverage new approaches to teaching and learning.[12] Unsuccessful technology projects are often the product of poor planning that is exacerbated by a general fear of change.[13, 14] Collaboration between Extension campuses, such as the University of California, Davis Extension and University of Wisconsin-Extension's embracing of micro-credentialing, can allay fears and change attitudes toward new technologies.[15]

Table 3: Comparison of "Final 12" Topics Across Three NMC Horizon Research Projects

NMC Horizon Report 2016 Museum Edition	2016 Technology Outlook for Cooperative Extension	NMC Horizon Report 2015 Library Edition
Time-to-Adoption Horizon: One Year or Less		
Bring Your Own Device Digital Humanities Technologies Electronic Publishing Makerspaces	Makerspaces Mobile Learning Online Learning Social Networks	Bring Your Own Device Electronic Publishing Makerspaces Online Learning
Time-to-Adoption Horizon: Two to Three Years		
3D Printing Digital Asset Discovery Location Intelligence Virtual Reality	3D Printing Big Data Drones Location Intelligence	Information Visualization Learning Analytics Preservation & Conservation Tech. Semantic Web and Linked Data
Time-to-Adoption Horizon: Four to Five Years		
Information Visualization Internet of Things Robotics Semantic Web and Linked Data	Internet of Things Robotics Telepresence Wearable Technology	Location Intelligence Machine Learning Quantified Self Virtual Assistants

Fueled by the key trends and impeded by significant challenges selected by the panel, the 12 important developments in technology presented in the body of this report reflect the experts' opinions as to which of the nearly 50 technologies considered will be most important to Cooperative Extension programs over the five years following the publication of the report. All three of these projects' expert panels strongly agree that makerspaces are on the cusp of widespread adoption — a trend that spans education across the world. For several years now, Paul Hill, Extension Associate Professor at Utah State University, has been leading the development of Cooperative Extension's engagement in the national Maker Movement.[16]

In the past year, location intelligence has increased in importance in museums, libraries, and Cooperative Education, propelled by the increasing power of mobile devices as well as the emergence of drones and wearables. Agents are analyzing the data generated by these location-aware devices to make changes in processes and aid in predictions. Additionally, institutions such as the University of New Hampshire Cooperative Extension are providing workshops on location intelligence for digital storytelling.[17] Jeff Hino, learning technology leader at Oregon State University working in Extension & Experiment Station Communications, has been researching and developing a concept paper and video about the impacts of the Internet of Things on Cooperative Extension.[18]

A number of unique choices distinguished the perspectives expressed by the 2016 Cooperative Extension panel from their counterparts. For example, they perceive social networks as an important development in technology on the near-term horizon. The ability for Cooperative Extension to leverage social networks to build communities of practice and reach new audiences is highly appealing. Similarly, another distinct selection, telepresence, represents a form of remote conferencing that has the potential to extend the reach of experts into new communities.

These points and comparisons provide an important context for the main body of the report that follows.

Key Trends Accelerating Technology Adoption

The technology developments featured in the NMC Horizon Project are embedded within a contemporary context that reflects the realities of the time, both in the sphere of education and in the world at large. To assure this perspective, each panel member identifies and ranks key trends that are currently affecting practices in Cooperative Extension programs, and uses these as a lens for the work of predicting the uptake of emerging technologies. These nine trends, which the panel agreed are very likely to drive technology planning and decision-making over the next five years, are sorted into three categories: long-term trends that will become increasingly pervasive in Cooperative Extension programs for five or more years, and mid- and short-term trends that have surfaced more recently and whose impact on Cooperative Extension programs may be briefer.

Long-Term Trends

Driving Ed Tech adoption in Cooperative Extension Programs for five or more years

Advancing Cultures of Innovation. Many thought leaders have long believed that education can play a major role in the growth of national economies.[19] In order to breed innovation and adapt to economic needs, Cooperative Extension programs must be structured in ways that allow for flexibility, and spur creativity and entrepreneurial thinking. The Clemson University Extension is fostering entrepreneurship through a new program where participants learn how to build successful businesses on limited resources.[20]Tuskegee University hosts the annual Booker T. Washington Economic Development Summit.[21]

Emergence of New Audiences. To lift the profile of their work outside of traditional stakeholders, Cooperative Extension must find ways to identify new audiences and deliver relevant information and programming to them. Increasingly, Extension programs are engaging with audiences where English is a second language and technologies such as real-time translation tools have the potential remove language barriers. At Texas A&M University-Commerce, they are expanding audiences by using Continuous Tone-Coded Squelch System encoders to allow greater outreach to Spanish-speaking farm owners.[22]

Shift from Learners as Consumers to Creators. A shift is taking place in the focus all over the world as learners across a wide variety of disciplines are learning by making and creating rather than from the simple consumption of content. Creativity, as illustrated by the growth of user-generated videos, maker communities, and crowdfunded projects in the past couple of years, is increasingly the means for active, hands-on learning. In the technology realm, Cooperative Extension at Montana State University has worked with 4-H leaders to design a curriculum that trains youth in digital storytelling and media production.[23]

Mid-Term Trends

Driving Ed Tech adoption in Cooperative Extension Programs for three to five years

Growing Focus on Measuring Learning. The proliferation of data mining software and developments within online learning, mobile learning, and learning management systems are coalescing toward learning environments that leverage analytics and visualization software to portray learning data in a multidimensional and portable manner. In online and blended courses, data can reveal how student actions contribute to progress and learning gains. Premium members of eXtension can use the new competency-based education features of the eXtension Campus service and use a new service through Intelliboard that allows course instructors to access analytics for Moodle courses.[24] At Michigan State University Extension, they recently completed a review of existing adaptive learning tools and have selected the adult learning courses that will serve as pilots.[25]

Redesigning Learning Spaces. New forms of teaching and learning require new spaces. As education continues to move away from traditional lecture-based programming and to more hands-on scenarios, the historic hands-on and real-life-context hallmark of Cooperative Extension programs is returning in new ways. New learning spaces resemble real-world work and social environments that facilitate organic interactions and cross-disciplinary problem solving. For example, the Ag Studies Academy, part of Cornell Cooperative Extension, is helping to train the next generation of farmers through a dedicated space with office, classroom, laboratory, as well as several outbuildings on tillable land and forest in order to provide a comprehensive introduction to agribusiness careers.[26]

Proliferation of Open Educational Resources. Defined by the Hewlett Foundation in 2002, open educational resources (OER) are "teaching, learning, and research resources that reside in the public domain or have been released under an intellectual property license that permits their free use and re-purposing by others." New Mexico State University Extension's Learning Games Lab develops open source digital games, apps, animations, and learning tools, which have been used more than 5 million times in the past year to help youth and adults nationwide learn food safety, lab skills, health, nutrition, mathematics, and science.[27]

Short-Term Trends

Driving Ed Tech adoption in Cooperative Extension Programs for one to two years

Communities of Practice. The rise of social networks and online learning has spurred the development of communities of practice (COP), defined by the Higher Education Academy as an informal partnership of learning among those with similar intellectual pursuits. They view learning as a collaborative experience for improving practice through problem-solving, collective thinking, and the exchange of new knowledge and ideas.[28] As technology changes the way cooperative extension professionals interact with formal and informal learners, it is important to keep abreast of the latest developments in disseminating credible knowledge. eXtension serves to provide a national digital presence for Cooperative Extension and hosts a variety of services and tools to further COP and learning networks, of which there are over 70 so far.[29]

Increasing Cross-Institution Collaboration. Collective action among institutions and programs is growing in importance for the future of learning. More and more, institutions are joining consortia — associations of two or more organizations — to combine resources or to align themselves strategically with learning innovation. Interest in cross-Institution Collaboration is growing in all three missions of the Land Grant Universities: education, research and Extension. ECOP, the representative leadership and governance committee of Cooperative Extension nationwide has a task force to identify methods for working together as a national system. The ECOP National Framework for Health and Wellness is one example of national cross-institution collaboration.[30]

Increasing Value of the User Experience. User experience (UX) refers to the quality of a person's interactions with a company's services and products. The term is commonly applied to assess computer-based exchanges with mobile devices, operating systems, and websites. Superior user experience has been largely attributed to the success of companies.[31] Easy navigation, digestible content, and practical features — among other components — are encompassed in effective website and database designs. Penn State's Atlas project exemplifies this growing trend in Cooperative Extension.[32]

Significant Challenges Impeding Technology Adoption

Along with the trends discussed in the preceding section, the expert panel noted a number of significant challenges faced in Cooperative Extension programs that are impeding the uptake of emerging technologies. Because not all challenges are of the same scope, the discussions here are sorted into three categories defined by the nature of the challenge. The NMC Horizon Project defines solvable challenges as those that we both understand and know how to solve; difficult challenges are ones that are more or less well understood, but for which solutions remain elusive. Wicked challenges, the most difficult, are categorized as complex to even define, and thus require additional data and insights before solutions will be possible.

Solvable Challenges

Those which we both understand and know how to solve

Blending Formal and Informal Learning. The internet has brought the ability to learn something about almost anything at the palm of one's hand. There is an increasing interest in the kinds of self-directed, curiosity-based learning that have long been common in Cooperative Extension, museums, science centers, and personal learning networks. Michigan State University Extension is creating the Michigan Informal Science Learning Network to address this challenge. Their goal is to understand how informal and non-formal science supports formal education through collaborating digitally.[33] Oregon State University Extension Open Campus provides college and career readiness, degree completion and economic and community development at County Extension Sites across the state.[34]

Embracing Change as a Constant. Higher education often lags behind commercial enterprises in the adoption of new technologies.[35] Lack of stakeholder involvement, unrealistic schedules, scope creep, and insufficient resources are cited as reasons for unsuccessful technology projects.[36] Adopting technologies may enable Cooperative Extension to better accomplish their missions and serve their audiences, but the community needs to become more flexible in its response to emerging trends. Events such as the recent Ohio State University Extension's InnovateExtension hackathon event, during which teams competed for grant funds after developing an idea, plan, and pitch, can show support for Cooperative Extension to embrace and encourage innovation in their state's organization and beyond.[37]

Promoting Extension Programs. Cooperative Extension agents, educators and specialists are highly skilled in their field of knowledge; however, they need to improve the way they market their services. Cooperative Extension professionals need to strengthen their communication channels such as social media, websites, and electronic newsletters to better reach their audiences.[38] To build greater awareness of the work of extension programs the Virginia Department of Education and Consumer Services highlighted the exceptional work of Virginia Cooperative Extension agents educators and specialists through an awards program and North Carolina State University Cooperative Extension has created a communication and marketing toolkit including customizable templates, file downloads, and branding guidelines.[39] A horticulture specialist at the University of Georgia Extension, Becky Griffin, learned new social media techniques at the eXtension conference that grew Becky's gardening blog website in July 2016 as Number 20 among the top 100 gardening blogsites.[40]

Difficult Challenges

Those we understand but for which solutions are elusive

Measuring the Impact of New Technologies. Cooperative Extension programs are increasingly leveraging emerging technologies such as mobile apps, social media, natural user interfaces, and augmented reality to add interactive elements to learning experiences. With the growing emphasis on the digital realm, some thought leaders fear that use of these tools is superseding the development of sufficient technology evaluation frameworks.[41] One panelist noted "many platforms also change their analytics model annually making it imperative we have someone on staff to update reporting systems. Some social media platforms have NO analytics so the real measurement cannot be gathered."

Staff Turnover and Training. Employee turnover is a threat to Cooperative Extension because it undermines progress in community relations and program impact. The field is currently seeing dramatic turnover as older professionals retire. Effective Extension employee training is needed to significantly improve how new and continuing agents and educators can meet their job expectations as well as helping them to feel more connected to the community they serve.[42]

Under-resourced Organizational Infrastructure. Rather than encouraging Extension professionals to expand core resources, leverage shared file systems, and open accessible service APIs, institutions are narrowing their focus to the minimal subset of enterprise services they can afford to sustain. Compounding this challenge is the scarcity mentality that exists within the field. The scarcity of resources such as time, equipment, technical expertise, money, and staff, is often used as an excuse to avoid new practices. If Cooperative Extension is to continue flourishing, leaders must reassess how they are delivering research-based information, solving local problems, and making local impact using evolving digital tools.

Wicked Challenges

Those that are complex to even define, much less address

Managing Knowledge Obsolescence. Simply staying organized and current presents a challenge in a world where information, software, tools, and devices proliferate at a rapid rate. New developments in technology are exciting, but it can be overwhelming to keep up with even a few of the many new tools that are released. There is a greater need than ever for effective tools and filters for finding, interpreting, organizing, and retrieving the data that is important to us. Regarding the challenge, a panelist explained, "our institution requires a review of all publications every three years to remain online. Unfortunately, there is less incentive to review a publication than to publish a new one."

Scaling Innovations. Cooperative Extension programs need to improve at moving learning innovations into mainstream practice. Scaling technological innovation requires adequate funding, capable leadership, and strong evaluation practices—a tall order for Extension programs strapped for resources. Fortunately, two Cooperative Extension offerings have the potential to scale innovative approaches. The eXtension Innovation Lab is helping to identify, incubate, and support the acceleration of innovation adoption and the Extension Educational Technology Learning Network has been established to show how to successfully integrate technology into practice.[43,44]

Teaching Complex Thinking. It is essential for people both to understand the networked world in which they are living in and also — through complex thinking — to learn how to use abstraction and decomposition when tackling complex tasks and to deploy heuristic reasoning to complex problems. Teaching coding is increasingly being viewed as a way to instill this kind of thinking in learners as it combines deep computer science knowledge with creativity and problem-solving. 4H programs are a mainstay of Cooperative Extension positive youth development in science, healthy living and citizenship.[45] As an example, Cornell Cooperative Extension and 4-H have teamed up to teach a summer program called "Learning to Program a Robot with Baxter," a course designed to teach the principles of computational thinking alongside robotics.[46]

Time-to-Adoption: One Year or Less

Makerspaces

The turn of the 21st century has signaled a shift in what types of skillsets have real, applicable value in a rapidly advancing world. The question of how to renovate or repurpose learning environments to address the needs of the future is being answered through the concept of makerspaces, or workshops that offer tools and the learning experiences needed to help people carry out their ideas.[47] Makerspaces are intended to appeal to people of all ages, and are founded on openness to experiment, iterate, and create. In this landscape, creativity, design, and engineering are at the forefront of educational considerations, as tools such as 3D printers, robotics, and 3D modelling web-based applications become accessible to more people. For Cooperative Extension programs, makerspaces are a natural fit because they are hands-on and skills-oriented by nature.[48] Professionals looking to gain actionable knowledge can learn with the tools they will be using in their careers, while community members have the opportunity to experiment with equipment as they develop their passions and career goals.

Relevance for Cooperative Extension Programs

- Makerspaces can bolster collaborations between extension educators and community leaders to develop hands-on programs with 21st century tools, making them available to people in rural areas that otherwise would not have access.
- Makerspaces equipped with technologies and construction supplies are all-purpose workshops that represent the power of creation in both the virtual and physical world.
- Pedagogies such as inquiry-based learning and design thinking, which encourage construction and higher-order thinking, can be carried out in makerspaces, leading to greater economic development.

Makerspaces in Practice

- Brunswick County Extension in North Carolina is developing a makerspace for local youth and their families. In addition to sewing machines and materials for sewing project groups, a greenhouse and garden space will be available. There are also plans to add computer programming activities, 3D printers, and drones: go.nmc.org/bruns.
- The eXtension Foundation recently hosted the webcast "Building and Managing Makerspaces in Extension" to help their land-grant educator and volunteer network foster authentic learning opportunities within their communities: go.nmc.org/webca.
- The Virginia Cooperative Extension 4-H Makers program encourages inventiveness in STEM subjects for youth through camps and events. Additionally, the program trains professionals and volunteers how to facilitate their own makerspaces: go.nmc.org/virg.

For Further Reading

Celebrating Connecticut's Makerspaces
go.nmc.org/celeb

(University of Connecticut Extension, 18 March 2016.) An extension professional at University of Connecticut explores makerspaces across the state, providing relevant links and context to why these environments are poised for positive impact in the field.

Extension and the Maker Movement
go.nmc.org/extand

(Paul A. Hill et al., *Journal of Extension*, February 2015.) The authors discuss how maker culture can be particularly beneficial in urban environments, connecting youth with the work of land-grant universities.

Time-to-Adoption: One Year or Less

Mobile Learning

As smartphones and tablets become more capable and user interfaces more natural, old methods of computing seem place-bound and less intuitive. People increasingly expect to be connected to the internet wherever they go, and the majority of them use a mobile device to do so. According to Pew Research Center, nearly two-thirds of Americans own smartphones, increasingly using them as their primary windows to online learning.[49] Learning institutions and their Extension programs across the US are adopting apps and modifying websites, educational materials, resources, and tools so they are optimized for mobile. These devices have the potential to facilitate almost any educational experience wherever there is internet access, even outdoors during fieldwork, allowing learners to organize video meetings with peers, use specialized software and tools, and collaborate on shared documents or projects in the cloud. A study conducted by the Harvard Business School reveals that access to mobile apps and resources helped agriculture and professionals in related fields to make smarter choices about equipment and processes.[50]

Relevance for Cooperative Extension Programs

- The advent of augmented and virtual reality, when integrated into mobile apps, can provide a foundation for detailed simulations, facilitating realistic opportunities for extension program participants to practice complex activities.
- Mobile apps with built-in social features enable community members to share questions or findings in real time. For example, social networking apps such as Twitter, LinkedIn, and Facebook make it possible to exchange ideas, notes, assignments, and videos.
- Mobile learning is particularly compelling in agriculture and environmental disciplines as smart devices lend themselves best to outdoor activities and data collection.

Mobile Learning in Practice

- The Clemson Cooperative Extension developed two iOS and Android apps to help agriculture professionals understand how to mix and calibrate their pesticide sprays: go.nmc.org/clemext.
- In collaboration with New Mexico State University's Learning Games Lab and Media Productions, The Ohio State University is training professionals to develop mobile apps and determine whether an app is the best course of action: go.nmc.org/osuext.
- University of Georgia Extension offers a series of mobile apps, including a guide to native plants across the state, a special calculator to estimate poultry ventilation rates, and a service forester toolkit: go.nmc.org/ugaext.

For Further Reading

Agricultural Mobile Apps Provide in the Field Support for Producers
go.nmc.org/kstateext

(K-State Research and Extension, 30 March 2016.) Kansas State University's Department of Agronomy worked with a group of crop production specialists to publish weekly "eUpdates" that suggest apps in categories such as livestock, irrigation, and machinery.

Agricultural Safety and Health Mobile Apps
go.nmc.org/safety

(eXtension Foundation, 23 April 2015.) The eXtension Foundation recommends informative apps for agricultural safety and education, including "FarmPAD," which stores farm records and equipment service logs, as well as "Chicken ROPS," a game that teaches users about the importance of tractor Rollover Protective Structures (ROPS).

Time-to-Adoption: One Year or Less

Online Learning

Online learning refers to both formal and informal educational opportunities that take place through the web.[51] Today, it is uncommon for learning institutions and programs to not have a web presence, and increasingly people expect for that to include learning modules and resources so that new knowledge and skills can be acquired on the go. This is especially pertinent for Cooperative Extension professionals who work outdoors, are learning on the job, or live in rural areas where face-to-face training is not always possible. In this sense, the advent of online learning is also helping Extension programs reach more people than ever before. The Ohio State University Extension, for example, developed a free, fully online course designed to educate patients and their loved ones on successful Type II diabetes management.[52] Similarly, digital badging at Colorado State University enables recognition for informal non-credit programming for broader audiences.[53] Both formal and informal educators are becoming more comfortable testing various levels of integration in their existing courses and programs, and many believe that online learning can be an effective catalyst for thoughtful discussion on all pedagogical practices.[54] For example, online learning, when coupled with immersive technologies like virtual reality, has potential to facilitate simulations that help participants better understand and respond appropriately to real-life environments and situations.

Relevance for Cooperative Extension Programs

- As new training methods emphasize personalized learning, there is a growing demand for learner-centered online opportunities. Online learning environments, when designed effectively, have the potential to scale across states and the country.
- Online learning makes creative use of educational technologies and emerging instructional approaches, including blended learning, virtual reality, simulations, gamification, video lectures, and digital badges.
- When placed online, a diverse set of learning resources is easily accessible to Cooperative Extension audiences and can support self-directed learning, promoting on-the-go training.

Online Learning in Practice

- eXtension's "i-Three Issue Corps: Virtual Local Food Project Field Trips" is part of a five-course online certificate series for local food systems professionals: go.nmc.org/ithree.
- Oregon State University's Open Campus is a statewide network that offers open access to learning for underserved and place-bound Oregonians, reaching families and other nontraditional learners: go.nmc.org/opcamp.
- University of Wisconsin Extension's Master Gardner program takes a flipped classroom approach; participants watch videos and read materials online prior to class, enabling higher-order learning to take place in person: go.nmc.org/wimaster.

For Further Reading

Blending Formal and Informal Learning Networks for Online Learning
go.nmc.org/irrodl

(Betul Czerkawski, *The International Review of Research in Open and Distributed Learning*, 2016.) A study reveals that online courses are not typically designed to consider variations in students' informal learning experiences.

New Online Course Focused on Feedlot Horse Handling and Care
go.nmc.org/ianrnews

(University of Nebraska-Lincoln, 29 April 2016.) A new online course from Nebraska Extension has been developed for feedlots to teach workers, pen riders, and processors about safe horse handling and care. This online certificate course is available 24/7, allowing cattle operations the flexibility of providing training to their workers as needed.

Time-to-Adoption: One Year or Less

Social Networks

Today's web users are prolific creators of content, uploading photographs, audio, and video to cloud-based social networks including Facebook, Twitter, YouTube, and many others by the billions. Leveraging this movement, Cooperative Extension programs are becoming more adept at creating micro-learning experiences through video lectures and demonstrations that can be easily shared across social networks to reach countless youth and agriculture professionals to teach them new skills.[55] While the initial emphasis of social networks was placed on producing and uploading media, it has ultimately evolved to become more about the conversations initiated and relationships formed via this media. Social media enables two-way dialogues between Cooperative Extension staff and the professionals they are training. LinkedIn, for example, is a professional networking platform that is particularly useful for learning because it facilitates communities of practice and special interest groups. The rise of Snapchat may also cause learning organizations to consider how they will incorporate a fast-paced network where the media shared by users are temporary.[56]

Relevance for Cooperative Extension Programs

- Engagement in social networks either as producers of content, consumers, or aggregators of user-generated content allow geographically dispersed Cooperative Extension staff and the professionals they are training to interact with each other and reach new audiences.
- Social networks enable participants to create powerful personal learning networks to direct and focus their own learning, which is particularly important for people who work outdoors or are constantly on the go.
- Video platforms including YouTube and Vimeo enable field experts and trainers to upload and share instructional videos. Similarly, tools such as Facebook Live and Google Hangouts allow them to connect around the content in real time.

Social Networks in Practice

- Military Families Learning Network, an initiative of eXtension, is a social network for military family service providers that provides access to timely research, the Cooperative Extension System, and virtual professional development: go.nmc.org/mfln.
- North Carolina State University Cooperative Extension's video series on healthy recipe preparation is posted to social media twice monthly with the goal of fostering a healthier community: go.nmc.org/curr.
- VIP, a parenting education program that uses web-based and multimedia platforms, is leveraging social media to reach and engage with teen parents: go.nmc.org/bevip.

For Further Reading

Six Easy Steps to Stretch Social Media Mileage
go.nmc.org/sixeasy

(Michele Walfred, eXtension.org, 9 November 2015.) Tips for Cooperative Extension staff to maximize social networking include the use of hashtags and the curation of print and digital collateral that enable participants become social media ambassadors.

Social Media Guidelines/Best Practices
go.nmc.org/umaine

(University of Maine Extension, accessed 11 August 2016.) UMaine Extension has adopted and posted social media guidelines and best practices that align with the university's communications policies as well as the National 4-H social media protocol.

Time-to-Adoption: Two to Three Years

3D Printing

Known in industrial circles as rapid prototyping, 3D printing refers to technologies that construct physical objects from three-dimensional (3D) digital content such as 3D modeling software, computer-aided design (CAD) tools, computer-aided tomography (CAT), and X-ray crystallography.[57] A 3D printer builds a tangible model or prototype from the electronic file, one layer at a time, through an extrusion-like process using plastics and other flexible materials, or an inkjet-like process to spray a bonding agent onto a very thin layer of fixable powder. The deposits created by the machine can be applied very accurately to build an object from the bottom up, layer by layer, with resolutions that, even in the least expensive machines, express a large amount of detail. This technology is commonly used in manufacturing to build three dimensional prototypes. Global 3D printer shipments are expected to double every year between 2016 and 2019, with the learning sector as a primary market driver.[58] The Cooperative Extension is well-positioned to cultivate important design, iteration, and production skills associated with 3D printing and modeling by providing learners with training. Increasing access to this technology through makerspaces can also lead to innovation and local economic development.

Relevance for Cooperative Extension Programs

- 3D printing allows for authentic exploration of objects that may not be readily available to people, including animal anatomies, ancient artefacts, and toxic materials.
- Advancements in 3D printing can help agriculture professionals to fabricate machine parts that are otherwise costly or time-consuming to repair.
- As a rapid prototyping and production tool, 3D printing shows promise, providing learners with the ability to touch, hold, and even take home concrete models of their ideas.

3D Printing in Practice

- Benton County 4-H Club Foundation received a grant from Cognizant's Making the Future Program to purchase 3D printers and related technologies. Participants completed nearly 200 projects and showcased the equipment at the County Fair: go.nmc.org/benton.
- Colorado State University Extension's Rio Verde Archaeology 3D artifacts dig is an interactive exhibit where young children learn about 3D printing and archaeology through play. Young participants excavate 3D-printed artifacts from a sand box and compare them to printed images of the actual object: go.nmc.org/3ddig.
- "ExTech Bits," an Oregon State University Extension Service video, demonstrates how 3D-printed objects can be incorporated into hands-on learning activities: go.nmc.org/extech.

For Further Reading

The Future of 3D Printing on the Farm
go.nmc.org/agweb

(Chris Bennett, *AG Web*, accessed 30 August 2016.) 3D printing and the agriculture industry are well-aligned, as farmers already possess a variety of mechanical engineering skills. The author posits future advantages of leveraging the technology.

How 3D Printing Facilitates Interactive Learning
go.nmc.org/how3dp

(Patricia Dimick, 3DPrint.com, 26 December 2015.) Because it is hands-on by nature, the act of 3D printing can spur deeper learning experiences by fostering excitement and curiosity in children. This article discusses how the technology can be best used for different ages groups.

Time-to-Adoption: Two to Three Years

Big Data

Today, almost any online interaction or consumption of goods and services is being tracked, stored, and used in targeted ways. This has led to the notion of big data — massive amounts of information that reflect the behavior and actions of various populations.[59] Data collection platforms are now able to computationally organize petabytes and exabytes of data so that data scientists can analyze and identify patterns that may have otherwise gone undetected. With the complexity surrounding such large, diverse sets of data, displaying the information is crucial to its success. Visual data analysis (VDA) blends highly advanced computational methods with sophisticated graphics engines to illuminate patterns and structures in even the most complex visual presentations.[60] In the education sector, data mining is already underway to target at-risk learners, personalize training, and create flexible pathways to new skill acquisition. As Cooperative Extension programs become more adept at working with and interpreting big data, they can make more informed decisions that reflect real learner needs.

Relevance for Cooperative Extension Programs

- Big data can be applied to solve pressing challenges and improve professional practices. For example, as more climate data, farming activities, and phenotypic crop information, are tracked, they can be used to inform models and best practices in the agriculture field.
- A geographic information system (GIS), an area of growing interest to the Cooperative Extension, captures and displays data related to geolocation. Many rely on GIS maps to understand pollution patterns and other environmental conditions that impact their work.
- Cooperative Extension programs can play a role in training people on specific visual data analysis tools and approaches for STEM fields.

Big Data in Practice

- Purdue University Extension helped found the Agricultural Data Coalition with the goal of developing a repository for farmers to securely store and manage their farms' production information: go.nmc.org/purdue.
- A researcher at the University of Delaware's College of Agriculture and Natural Resources received a national grant to bridge the gap between managing big data and the statistical methods and tools needed to analyze it: go.nmc.org/udbig.
- University of Wisconsin Cooperative Extension is leveraging shared analytic tools and methods to more effectively analyze massive data sets such as thousands of impact statements in the context of re-organizations or federal reviews: go.nmc.org/qual.

For Further Reading

3 Jobs that Big Data Projects Affect in Major Ways
go.nmc.org/3jobs

(Mary Shacklett, *Tech Republic*, 29 August 2016.) Office workers, commercial truck drivers, and GIS managers are all benefiting from big data initiatives that enable them to track and monitor progress while anticipating future challenges.

Big Data Project at U. of I. Gets Boost from $110 Million Grant
go.nmc.org/xsede

(Ally Marotti, *Chicago Tribune*, 30 August 2016.) The University of Illinois at Urbana-Champaign's Extreme Science and Engineering Discovery Environment has received significant funding to connect researchers to supercomputers and high-end visual data analysis tools to create a better infrastructure for big data access and analysis.

Time-to-Adoption: Two to Three Years

Drones

Drones are unmanned aerial vehicles that are controlled autonomously by computers or pilots with remote controls. Innovated in the early 1900s, they were used by the military as training tools for target practice and to gather intelligence.[61] Since then, drones have been deployed for a wide range of tasks, such as community surveillance and security, disaster response, improved weather forecasting, non-invasive wildlife monitoring, and the surveying of agriculture and crops.[62] Drone technology has advanced users' abilities to extensively view objects and landscapes, as well as to detect changes in environmental conditions. Features including biological and chemical sensors, electromagnetic spectrum sensors, and infrared cameras make these detailed observations possible.[63] While legal and ethical concerns have been raised by many over the prospect of constantly being monitored by these vehicles, new civil aviation programs and experiments that include drones reflect a growing use of the technology.[64] The FAA released updated regulations for non-hobbyist small unmanned aircraft system operation that will help integrate drones into the national airspace and provide more favorable conditions for researchers in a number of Cooperative Extension programs.[65] The Association for Unmanned Vehicle Systems International has predicted that 80% of the commercial market for drones will be for agricultural uses.[66]

Relevance for Cooperative Extension Programs

- Combined with other technologies, drones can extend specialized knowledge across the country, including live coverage of events, to inform more robust study of and responses to environmental issues and natural or biological hazards.
- Drones can benefit data collection techniques, fieldwork, and the roles of professionals by automating manual tasks and providing a thorough picture of large-scale systems.
- Drones will be valuable in providing information for educational programming including crop and animal health, environmental impacts of large events like floods, and volume estimation.

Drones in Practice

- Cornell University Cooperative Extension developed an experiential design challenge as part of the annual 4-H National Youth Science Day, inviting youth to experiment with drone-related wing design, remote sensing, and coding: go.nmc.org/4hyouth.
- The fourth annual Unmanned Systems in Precision Agriculture Conference shared the latest research and proposed federal and state regulations on agricultural drone use with Cooperative Extension personnel, farmers, and researchers: go.nmc.org/ugeorg.
- The Sustainable Forests Education Cooperative at the University of Minnesota recently offered a workshop to introduce natural resource managers to potential applications of unmanned aerial systems in their forest and land management work: go.nmc.org/uasland.

For Further Reading

Drones: Agriculture from Above
go.nmc.org/agabove
(Jake Zuckerman, *The Northern Virginia*, 30 June 2016.) Virginia Cooperative Extension is working with Cornerstone Technology Services to use drones for crop monitoring.

Land-Grant Universities at the Forefront of Unmanned-Aircraft Research and Testing
go.nmc.org/restes
(eXtension.org, 1 June 2016.) Land-grant universities are playing a major role in research and testing of unmanned aircraft applications including newsgathering, collecting soil and water samples, and monitoring the health of forests, crops, and water bodies.

Time-to-Adoption: Two to Three Years

Location Intelligence

Location intelligence refers to the mapping of the geographic relationships associated with data. Resources including GIS are used to provide individuals and organizations with information and visualizations, portraying how people are interacting with various applications and services based on their location.[67] Smartphones and tablets are naturally driving the proliferation of this technology because of their built-in location-sensitive sensors and other features. Extension professionals are currently using GIS software to share data, educate others, and inform decision-making by mapping information such as natural resources and community assets, like town halls, sports facilities, or libraries.[68] Understanding spatial relationships is vital to planning and management of resources in a number of fields including agriculture, engineering, and health services. With the convenience of accessing a visual interface that can view, analyze, and manipulate data on a mobile device, researchers, professionals, and community members can more effectively and remotely visualize trends at a micro or macro level, as well as handle risks and resource management, generating greater cost saving and timely decision-making.[69]

Relevance for Cooperative Extension Programs

- Analysis of data collected through location-aware and GIS tools informs educators, researchers, and professionals on current processes and helps them make changes and predictions toward improved economic outcomes.
- Extension initiatives that familiarize practitioners and community members with GIS tools are helping them effectively collect and understand data related to their fields of interest.
- Location-aware features are a major component of other emerging technologies including drones and wearable devices that are driving innovation in a number of extension fields, such as precision agriculture.

Location Intelligence in Practice

- Cornell Cooperative Extension is working with local youth in their Community Mapping Program to conduct biodiversity inventories with GPS and GIS mapping: go.nmc.org/biod.
- Map@Syst is an area of the eXtension foundation devoted to providing geospatial technology resources along with outreach and education on the application of geospatial technologies in today's world: go.nmc.org/exgeo.
- University of New Hampshire Cooperative Extension provides workshops on using GIS for creating and manipulating maps that tell stories and provide guidance related to community planning: go.nmc.org/mapguid.

For Further Reading

Helping Farmers Access Farmland: New Jersey's New Land Link Website
go.nmc.org/landlink

(Brian J. Schilling et al., *Journal of Extension*, December 2015.) The NJ Land Link interactive web portal has been designed to improve access to farmland and farming opportunities in New Jersey through a GIS-enabled searchable database of detailed farmland.

Learning from Location
go.nmc.org/learnloc

(Laura Adler, Data-Smart City Solutions, 24 March 2016.) The author describes the benefits and challenges for leveraging the location information encoded in the data that residents choose to share on a regular basis. Communities can use location information to learn about public safety issues and provide access to local goods and services.

Time-to-Adoption: Four to Five Years

Internet of Things

Internet of Things link the physical world with the world of information through the web. In internet of Things, embedded chips, sensors, or tiny processors are attached to an object and can transmit information about it, such as age, size, and temperature, to another smart device or piece of machinery. This connection allows remote management, status monitoring, tracking, and alerts if the objects are in danger of being damaged. The capabilities of constant access to transmitted information on the state of both inanimate objects and living organisms like crops and humans will continue to affect a number of industries that Cooperative Extension targets. Farmers are beginning to use sensors to better monitor factors like chlorophyll levels and plant water status in precision agriculture. Further impacting health, both patients and doctors will benefit from a more preventative model of healthcare that leverages wearable, implantable, or digestible sensors to track and transmit data like daily vitals, activity rates, diet, and medication adherence. Personal health data can empower users in better assessing and adjusting their own habits to maintain their health, while also informing Extension health specialists.[70]

Relevance for Cooperative Extension Programs

- Data from sensors on farm equipment and plants, combined with satellite images and weather tracking, will lead to higher productivity on farms. Consumers can access data on amounts of water and chemicals used, as well as when and how food was harvested.[71]
- In rural communities, smart home systems can leverage sensors to remind residents with cognitive decline to take medication, prepare meals, and engage in physical therapy.[72]
- Smart gardening systems can help people more effectively grow their own produce, while sensors in food packaging could alert people of signs of decay or allergens.[73, 74]

Internet of Things in Practice

- UC Irvine Extension offers an online specialization in the Internet of Things through Coursera; trainings focus on current IoT devices and trends: go.nmc.org/uci.
- University of Minnesota Extension performed a study of 300 cows fitted with rumination/activity sensors that found significant associations between rumination time/activity and disorders: go.nmc.org/cowsens.
- University of Nebraska-Lincoln Extension's Project SENSE (Sensors for Efficient Nitrogen Use and Stewardship of the Environment) is using crop canopy sensors attached to nitrogen applicators to measure nitrogen levels in plants and automatically apply the appropriate amounts of fertilizer: go.nmc.org/sense.

For Further Reading

From Dirt to Data: The Second Green Revolution and the Internet of Things
go.nmc.org/dirtdata

(Will Sarni et al., *Deloitte University Press*, January 25, 2016.) This article argues that the world is on the cusp of a second green revolution that will likely leverage IoT technologies to inform more effective and efficient farming practices grounded in data.

Seven Reasons You Should Care About the Internet of Things
go.nmc.org/sevenrea

(Jeff Hino, eXtension, 23 October 2015.) An Extension Fellow explains the implications of IoT, and why Extension professionals must prepare to help community members adapt to new skill set demands, data challenges, and personal health management opportunities.

Time-to-Adoption: Four to Five Years

Robotics

Robotics refers to the design and application of robots — automated machines that accomplish a range of activities. The first robots were integrated into factory assembly lines in order to streamline and increase the productivity of manufacturing, most notably for cars. Today, the role of robots in mining, transportation, and the military has helped improve operations for industries as they perform tasks that are unsafe or tedious for humans.[75] The global robot population is expected to double to four million by 2020 — a shift that will impact business models and economies worldwide,[76] with the market to be worth $135 billion in 2019.[77] While robotics was identified as four to five years away from mainstream use in Cooperative Extension programs, robots are already assisting people in areas including agriculture and disaster response. Meanwhile, 4-H programs are facilitating hands-on experiences in building and programming robots, encouraging youth to innovate and discover new uses and capabilities for robotics.[78]

Relevance for Cooperative Extension Programs

- 4-H robotics programs encourage young participants to gain confidence in science, technology, engineering, and mathematics (STEM) subjects and recognize their creative capacities while gaining valuable computational and critical thinking skills.[79]
- Farmers are leveraging robots for planting, fertilizing, and harvesting ripe produce, collecting data on soil composition and plant health, and measuring plant water needs.[80]
- Robots can carry out dangerous tasks, which could aid Extension professionals in environmental fields by keeping workers safe from hazardous conditions and during community emergencies.

Robotics in Practice

- The 4-H Robotics Youth Development Program in Mississippi, a partnership between MSU Extension Center for Technology Outreach and Mississippi State University Extension, engages youth to find solutions to real world problems: go.nmc.org/robrev.
- Residents of Lilac Hills Ranch in California will soon vote on a project to incorporate robots into the community that can assist in various capacities, including acting as chauffeurs for residents to encourage safe walking and running, assisting with carrying groceries home, or serving as designated drivers: go.nmc.org/lilac.
- The Virginia Cooperative Extension Services hosts regular meetings as well as a Facebook group for farmers using robotic milking machines to discuss issues associated with using their robots and share best practices: go.nmc.org/virgi.

For Further Reading

Future Farming with Robotics
go.nmc.org/withrob

(Ann Marie Edwards, *Iowa Farmer Today*, 25 June 2016.) An increasing strain on food supplies, availability of farm labor, and expenses of hiring farm workers are among the driving forces behind demand for agriculture robots. 4-H programs are preparing youth for this future demand through robotics programming and competitions.

Scientists Unveil Robot that Makes Plant Grafting a Snap
go.nmc.org/graft

(Clemson University, Phys.org, 15 March 2016) Clemson Cooperative Extension's South Carolina state vegetable specialist discusses a robot that has been successfully developed for plant grafting, a slow and labor-intensive process when done by hand.

Time-to-Adoption: Four to Five Years

Telepresence

Telepresence is a form of remote conferencing in which the participants appear to be physically present in a space. Body language cues such as eye contact are easily transmitted and interpreted,[81] making collaboration feel more seamless and replicating the benefits of face-to-face communication. Cisco has recently demonstrated a holographic telepresence system that captures images and sounds of users and environments and projects them in another location using laser beams.[82] Microsoft's Room2Room project is testing how the Microsoft Kinect gaming console can track movements and gestures of remote users and render them realistically in another space.[83] These technologies can enable real-time collaboration between geographically dispersed groups who may otherwise be hindered by cost or logistics.[84] Cooperative Extension professionals can monitor hazardous areas or attend remote events that inform their work, even projecting themselves in a locale to engage with community members.

Relevance for Cooperative Extension Programs

- Cooperative Extension professionals and community members can explore and gain insight of areas they cannot access on a day-to-day basis by leveraging a telepresence system to participate in research expeditions.[85]
- For teaching, learning, and sharing expertise, telepresence robots can enable remote experts to consult with and extend information to communities.[86]
- Telepresence robots can connect confined community members with disabilities or illnesses to events and activities, allowing them to attend and interact with others.[87]

Telepresence in Practice

- A Georgetown Learning Initiative course composed of both students living in the United States and Qatar is leveraging telepresence to create a mixed virtual experience that is immersive: go.nmc.org/gli.
- Florida International University's is deploying a telepresence robot that allows one professor to simultaneously teach students in both Miami and China: go.nmc.org/fiu.
- The University of Virginia Health System's Center for Telehealth allows medical professionals to leverage video-teleconferencing units so they can evaluate remote patients right away, especially valuable in rural areas: go.nmc.org/uvatele.

For Further Reading

3 Districts Share Their Telepresence Success Stories
go.nmc.org/distshare

(Jacquelyn Bengfort, *EdTech Magazine*, 9 January 2016.) A number of school districts are allowing students to attend class virtually during inclement weather or illness. Telepresence technology can further help students access courses offered remotely, providing rural schools with more educational options and resources.

Making Friends with a Telepresence Robot
go.nmc.org/makingfrien

(Ron Carrico, *San Diego Source*, 18 May 2015.) A museum docent describes the experience of giving tours to two quadriplegic visitors at the San Diego Air and Space Museum using a Beam Pro Presence System. The museum has found the Beam to be a valuable tool for extending museum offerings to those who cannot easily travel.

Time-to-Adoption: Four to Five Years

Wearable Technology

Wearable technology refers to smart devices that can be worn by users, often taking the form of an accessory. Smart textiles also allow items of clothing to interact with other devices. The wearable format enables the convenient integration of tools into users' everyday lives, allowing seamless tracking of personal data on sleep, movement, location, social media interactions, and more. CCS Insight anticipates that by 2020, the global wearable technology market will grow to $34 billion, with 411 million wearable devices sold.[88] With roots in the quantified self movement, today's wearables not only track where people go, what they do, and how much time they spend doing it, but their aspirations and when those can be accomplished.[89] Wearables such as the FitBit collect data in order to change wearer behavior by identifying and encouraging healthy habits through alerts and reminders.[90] Headsets and haptic suits are also being developed that could be used for hands-on job training, such as simulating dangerous situations to prepare emergency medical responders for facing real dangers in the field.[91] Further, wearables enable the collection of valuable data that can inform the development of policies, guidelines, and procedures for community planning and protecting the health of workers.

Relevance for Cooperative Extension Programs

- Fitness trackers and health devices will continue to advance in the levels of data they capture. Extension health specialists can help users understand the data to develop better personal health and nutrition plans.
- In agriculture, wearables are being investigated to capture environmental data including noise and dust levels to identify hazards and implement safety measures for workers.[92]
- Wearable virtual reality devices may become valuable training tools for Extension professionals to facilitate immersive, interactive learning experiences, placing users in real-world scenarios.[93]

Wearable Technology in Practice

- The eXtension Foundation is expanding its Wearable Technology Learning Network to explore how wearables can monitor biometrics of agricultural workers, mitigating issues such as machinery accidents and heat illness: go.nmc.org/wearnetwork.
- Nebraska's 4-H WearTec project explores how designing wearable technology using the Arduino LillyPad ecosystem can support student comprehension of the engineering design process and build interest in STEM subjects: go.nmc.org/weartec.
- Texas A&M AgriLife Extension is investigating the learning process of users who wear biometric equipment with eye-tracking to assess visual attention and brain activation: go.nmc.org/eyetra.

For Further Reading

Luddites, Beware: These 5 Livestock Wearables Are the Future
go.nmc.org/ludd
(Brian Barth, *Modern Farmer*, 28 January 2016.) Wearables for livestock can help owners effectively manage animals by alerting them to changes in body temperature, heart rate, respiration rate, pH levels, and other basic health parameters.

Style Engineers Teach Science of Fashion to N.Y. Girls
go.nmc.org/style
(Ted Boscia, *Cornell Chronicle*, 31 August 2015.) Cornell's Department of Fiber Science & Apparel Design worked with Cornell Cooperative Extension and local partners to develop a curriculum implemented at 4-H Camps that covered technical disciplines related to fashion design with a module specifically on smart clothing and wearable technology.

Methodology

The process used to research and create the *2016 NMC Technology Outlook for Cooperative Education: A Horizon Project Sector Report* is very much rooted in the methods used throughout the NMC Horizon Project. All publications of the NMC Horizon Project are produced using a carefully constructed process that is informed by both primary and secondary research. Dozens of technologies, meaningful trends, and critical challenges are examined for possible inclusion in the report for each edition. Every report draws on the considerable expertise of an internationally renowned panel of experts that first considers a broad set of important emerging technologies, challenges, and trends, and then examines each of them in progressively more detail, reducing the set until the final listing of trends, challenges, and important developments in educational technology is selected.

Much of the process takes place online, where it is captured and placed in the NMC Horizon Project wiki. This wiki, which has grown into a resource of hundreds of pages, is intended to be a completely transparent window onto the work of the project, and contains the entire record of the research for each of the various editions. The section of the wiki used for the *2016 NMC Technology Outlook for Cooperative Extension* can be found at extension.wiki.nmc.org.

The procedures for selecting the topics that are in this report include a modified Delphi process now refined over years of producing the *NMC Horizon Report* series, and it began with the assembly of the expert panel. The panel as a whole was intended to represent a wide range of backgrounds and interests, yet with each member bringing a particularly relevant expertise. To date, hundreds of internationally recognized practitioners and thought leaders have participated in the NMC Horizon Project Expert Panel; in any given year, a third of expert panel members are new, ensuring a flow of fresh perspectives.

Once the expert panel for a particular edition is constituted, their work begins with a systematic review of the literature — press clippings, reports, essays, and other materials — that pertains to emerging technology. Panel members are provided with an extensive set of background materials when the project begins, and are then asked to comment on them, identify those that seem especially worthwhile, and add to the set. The group discusses existing applications of emerging technology and brainstorms new ones. A key criterion for the inclusion of a topic is the potential relevance of the topic to teaching, learning, or creative inquiry. A carefully selected set of RSS feeds from dozens of relevant publications ensures that background resources stay current as the project progresses. They are used to inform the thinking of the participants throughout the process.

Following the review of the literature, the expert panel engages in the central focus of the research — the research questions that are at the core of the NMC Horizon Project. These questions are designed to elicit a comprehensive listing of interesting technologies, challenges, and trends from the panel:

1. *Which of these key technologies will be most important to Cooperative Extension programs within the next five years?*
2. *What key technologies are missing from our list? Consider these related questions:*
    a. *What would you list among the established developments in technology that some Cooperative Extension programs are using today that arguably ALL Cooperative Extension programs should be using broadly to support or enhance teaching, learning, or creative inquiry?*
    b. *What technologies that have a solid user base in consumer, entertainment, or other industries should Cooperative Extension programs be actively looking for ways to apply?*

   c. *What are the key emerging technologies you see developing to the point that Cooperative Extension programs should begin to take notice during the next four to five years?*

3. *What key trends do you expect to accelerate the uptake of emerging technology across Cooperative Extension programs?*
4. *What do you see as the significant challenges impeding emerging technology uptake across Cooperative Extension programs?*

One of the expert panel's most important tasks is to answer these questions as systematically and broadly as possible, so as to ensure that the range of relevant topics is considered. Once this work is done, a process that moves quickly over just a few days, the expert panel moves to a unique consensus-building process based on an iterative Delphi-based methodology.

The responses to the research questions are systematically ranked and placed into adoption horizons by each panel member using a multi-vote system that allows members to weight their selections. Each member is asked to also identify the timeframe during which they feel the technology would enter mainstream use — defined for the purpose of the project as about 20% of institutions adopting it within the period discussed. (This figure is based on the research of Geoffrey A. Moore and refers to the critical mass of adoptions needed for a technology to have a chance of entering broad use.) These rankings are compiled into a collective set of responses, and inevitably, the ones around which there is the most agreement are quickly apparent.

For additional detail on the project methodology or to review the instrumentation, the ranking, and the interim products behind the report, please visit the project wiki, which can be found at extension.wiki.nmc.org.

2016 Horizon Project Cooperative Extension Expert Panel

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New Media Consortium

Christine Geith
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Brian Higginbotham
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Montana State University

Dan Thiede
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Kate Venturini
University of Rhode Island

Michele Walfred
University of Delaware

Terrence Wolfork
Fort Valley State University

End Notes

[1] https://library.educause.edu/resources/2015/7/7-things-you-should-know-about-crossinstitutional-collaboration
[2] http://imaginingamerica.org/initiatives/extension-reconsidered/
[3] https://extension.org/2016/06/30/new-moodle-analytics-service-provides-multiple-views-of-course-effectiveness/
[4] https://faculty.tamuc.edu/jlopez/documents/2012AAAE-Rojas-et-al.pdf (PDF)
[5] https://www.cals.ncsu.edu/agcomm/news-center/perspectives/new-simulator-brings-farm-experience-to-urban-areas/
[6] http://mavsocial.com/the-impact-of-user-generated-content/
[7] http://www.extedtechs.org/
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