NMC

Horizon Report > 2014 K-12 Edition

The *NMC Horizon Report: 2014 K-12 Edition* examines emerging technologies for their potential impact on and use in teaching, learning, and creative inquiry in schools

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Introduction

The internationally recognized *NMC Horizon Report* series and regional *NMC Technology Outlooks* are part of the NMC Horizon Project, a 12-year effort established in 2002 that annually identifies and describes emerging technologies likely to have a large impact over the coming five years in every sector of education in some 65 countries around the globe. This volume, the *NMC Horizon Report: 2014 K-12 Edition*, examines emerging technologies for their potential impact on and use in teaching, learning, and creative inquiry in schools. While there are many local factors affecting the practice of education, there are also issues that transcend regional boundaries and questions common to K-12 education; it was with these questions in mind that this report was created. The *NMC Horizon Report: 2014 K-12 Edition* is the sixth in the annual K-12 education series of reports and is produced by the NMC in collaboration with the Consortium for School Networking (CoSN).

Each of the three global editions of the *NMC Horizon Report* — higher education, K-12 education, libraries, and museums — highlights six trends, challenges and emerging technologies that are likely to enter mainstream use within their focus sectors over the next five years. Key trends and challenges that will affect current practice over the same period frame these discussions. For the *NMC Horizon Report: 2014 K-12 Edition*, an expert panel identified 18 topics very likely to impact technology planning and decision-making: six key trends, six significant challenges, and six important developments in educational technology. The discussions of trends and technologies have been organized into three time-related categories; challenges are discussed within a similar three-part framework related to the scope of the challenge.

To create the report, an international body of experts in education, technology, and other fields was convened as a panel. Over the course of three months in the winter and spring of 2014, the 2014 NMC Horizon Project K-12 Expert Panel came to a consensus about the topics that would appear here in the *NMC Horizon Report: 2014 K-12 Edition*.

The framework of the "Up-Scaling Creative Classrooms in Europe" (CCR) project, developed by the European Institute for Prospective Technological Studies (IPTS) on behalf of the Directorate-General on Education and Culture and pictured in the chart on page 4, was used to surface the systemic implications of the six trends and six challenges.[1] The CCR Framework sees learning environments, wherever they may be found, as "live ecosystems" that evolve over time, changing in tune with the context and culture in which they reside. The framework focuses on the systemic approaches that are needed to scale up innovative pedagogical practices, especially in ICT-enabled learning settings.

Over the course of three months, the 2014 NMC Horizon Project K-12 Expert Panel came to a consensus about the topics that would appear here in the *NMC Horizon Report: 2014 K-12 Edition*.

Each topic closes with an annotated list of suggested readings and additional examples that expand on the discussion in the report. These resources, along with a wide collection of other helpful projects and readings, can all be found in the project's open content database that is accessible via the free NMC Horizon EdTech Weekly App for iOS[2] and Android devices.[3] All the background materials for the *NMC Horizon Report: 2014 K-12 Edition*, including the research data, the preliminary selections, the topic preview, and this publication, can be downloaded for free on iTunes U.[4]

The process used to research and create the *NMC Horizon Report: 2014 K-12 Edition* is rooted in the methods used across all the research conducted within the NMC Horizon Project. All editions of the *NMC Horizon Report* are informed by both primary and secondary research. Dozens of meaningful trends, challenges, and emerging technologies are examined for possible inclusion in the report for each edition.

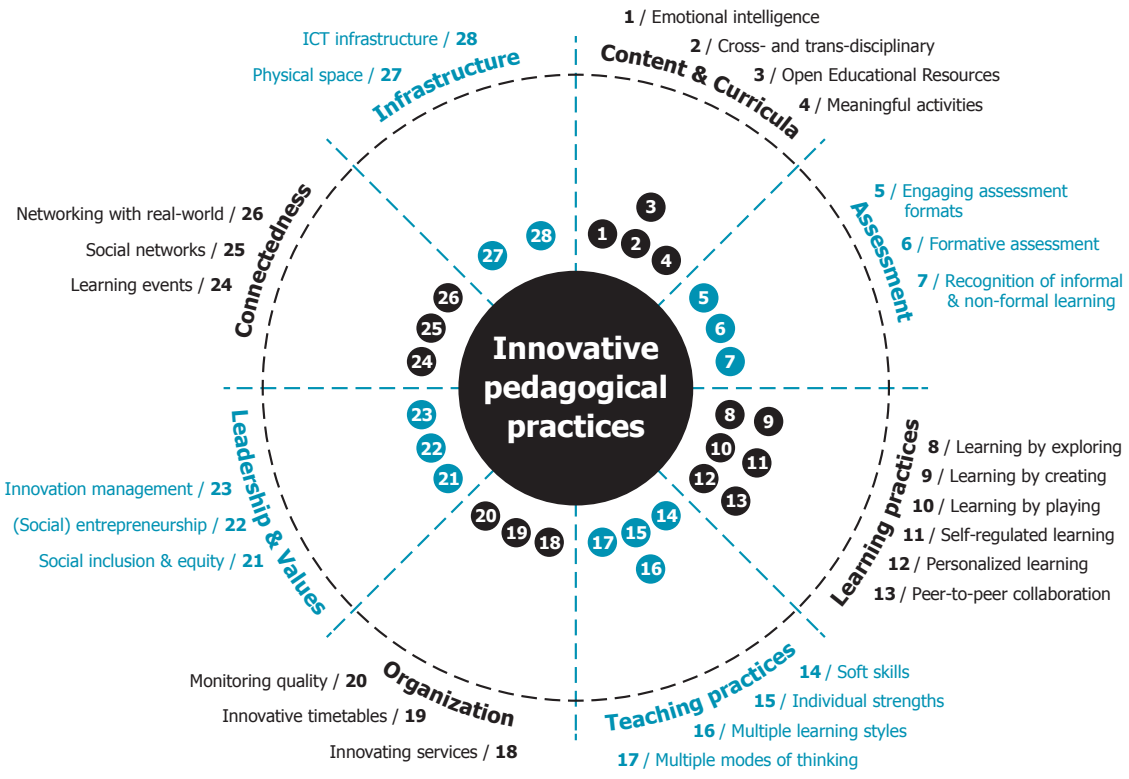
Every report draws on the considerable expertise of an international expert panel that first considers a broad set of important trends, challenges, and emerging technologies, and then examines each of them in progressively more detail, reducing the set until the final listing of trends, challenges, and technologies is selected. This process takes place online, where it is captured in the NMC Horizon Project wiki. The wiki is intended to be a completely transparent window into the work of the project, one that not only provides a real-time view of the work as it happens, but also contains the entire record of the process for each of the various editions published since 2006. The wiki used for the *NMC Horizon Report: 2014 K-12 Edition* can be found at k12.wiki.nmc.org.

The panel was composed of 53 technology experts from 18 countries on six continents this year; their names and affiliations are listed at the end of this report. Despite their diversity of backgrounds and experience, they share a consensus view that each of the profiled technologies is going to have a significant impact on the practice of K-12 education around the globe over the next five years. Also representing the experts' perspectives are the key trends driving interest in their adoption, and the significant challenges schools will need to address if these technologies are to successfully see mainstream adoptions.

The procedure for selecting the topics in the report is based on a modified Delphi process refined over 12 years of producing the *NMC Horizon Report* series, and began with the assembly of the panel. The panel represents a wide range of backgrounds, nationalities, and interests, yet each member brings a relevant expertise. Nearly 1,000 internationally recognized practitioners and experts have participated on one or more panels since 2002. For any given edition, at least a third of panel members are new, ensuring a flow of fresh perspectives each year. Nominations to serve on the expert panel are encouraged; see go.nmc.org/horizon-nominate.

Once the panel for a particular edition is constituted, their work begins with a systematic review of press clippings, reports, essays, and other materials that pertain to the growth and evolution of emerging technology. 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

Elements of the Creative Classroom Framework



emerging technology and brainstorms new ones. A key criterion for the inclusion of a topic in this edition is its potential relevance to teaching, learning, and creative inquiry in K-12 education. A carefully selected set of RSS feeds from hundreds of relevant publications ensures that background resources stay current as the project progresses. They are used to inform the thinking of the participants.

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

1 What trends do you expect to have a significant impact on the ways in which schools approach our core missions of teaching, learning, and creative inquiry?

2 What do you see as the key challenges related to teaching, learning, or creative inquiry that schools will face during the next five years?

3 Which of the key technologies catalogued in the NMC Horizon Project Listing will be most important to teaching, learning, or creative inquiry in K-12 education within the next five years?

4 What key technologies are missing from our list? Consider these related questions:

- **What would you list among the established technologies that some schools are using today that arguably *all* schools should be using broadly to support or enhance teaching, learning, or creative inquiry?**
- **What technologies that have a solid user base in consumer, entertainment, or other industries should schools be actively looking for ways to apply?**
- **What are the key emerging technologies you see developing to the point that schools should begin to take notice during the next four to five years?**

In the first step of this approach, the responses to the research questions are systematically ranked and placed into adoption horizons by each expert panel member using a multi-vote system that allows members to weight and categorize their selections. These are compiled into a collective ranking, and inevitably, the ones around which there is the most agreement are quickly apparent.

From the comprehensive list of trends, challenges, and technologies originally considered for any report, the dozen that emerge at the top of the initial ranking process in each area are further researched and expanded. Once these interim results are identified, the group explores the ways in which these topics impact teaching and learning in schools. A significant amount of time is spent researching real and potential applications for each of the topics that would be of interest to practitioners. For every edition, when that work is done, each of these interim results topics is written up in the format of the *NMC Horizon Report*. With the benefit of the full picture of how the topic will look in the report, the topics in the interim results are then ranked yet again, this time in reverse. The final topics selected by the expert panel are those detailed here in the *NMC Horizon Report: 2014 K-12 Edition*.

Key Trends Accelerating Educational Technology Adoption in Schools

The six trends described in the following pages were selected by the project's expert panel in a series of Delphi-based voting cycles, each accompanied by rounds of desktop research, discussions, and further refinements of the topics. These trends, which the members of the expert panel agreed are very likely to drive technology planning and decision-making over the next five years, are sorted into three movement-related categories — fast-moving trends that will realize their impact in the next one to two years, and two categories of slower-moving trends that will realize their impact within three to five or more years. All of the trends listed here were explored for their implications for schools in a series of online discussions that can be viewed at k12.wiki.nmc.org/Trends.

The framework of the "Up-Scaling Creative Classrooms" (CCR) project, illustrated in the executive summary, was used to map implications related to each of the six trends discussed in this section. The CCR Framework places learning environments, wherever they may occur, as part of an ecosystem that evolves over time, and that is very responsive to the context and culture in which they reside. The eight-dimensional model is systemic by nature, and encourages the design of multi-dimensional approaches when scaling up innovative pedagogical practices, especially in ICT-enabled learning settings.

The NMC Horizon Project model derived three meta-dimensions from the CCR framework that were used to focus the discussions of each trend and challenge: policy, leadership, and practice. Policy, in this context, refers to the formal laws, regulations, rules, and guidelines that govern schools; leadership is the product of experts' visions of the future of learning, based on research and deep consideration; and practice is where new ideas and pedagogies take action, in schools, classrooms, and related settings.

Policy. While all of the identified trends had policy implications, two trends in particular are expected to have a strong impact on policy decisions over the next five years. It is widely agreed that expectations for teachers are evolving rapidly, especially as student-centered learning and flipped classroom models are increasingly emphasized by departments of education and school administrations. In Europe, for example, the European Commission's Creative Classrooms Lab recently convened a Policy Makers Workshop to develop standards for successful flipped classroom implementation and their consensus was documented in a report, *Policy Maker Scenario: Flipped Classroom*, which calls for teachers to use emerging technologies to support their roles as guides and coaches in the classroom.[5]

While the panel experts also believe that the trend toward use of hybrid learning designs will reach its maximum impact in schools in three to five years, policy makers are already taking important actions to design effective approaches and protocol. The U.S. Department of Education is currently developing a rotational design model that weaves online activities into classroom practices. Early studies have revealed that the hybrid learning instruction improved performance in mathematics. They are using this research to inform policy creation.[6]

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Leadership. Although there are leadership implications highlighted for all the identified trends as well, two trends stand out as unique opportunities for vision and leadership. First, the rise of open educational resources (OER) is creating opportunities for schools to take advantage of high-quality, free content for both teaching and learning. Although the panel perceives this trend to be three to five years away from widespread adoption, in some cases school leaders are implementing their visions at a large scale. The state of Utah is leading this charge in many ways, with their well-publicized open textbook initiatives and the open

model embodied by The Open High School of Utah, in which students exclusively use OER for all of their online studies.[7]

There is a growing awareness within national governments that the traditional classroom-focused paradigm falls short in critical ways, and school leaders in several countries are rethinking the ways schools are designed entirely. In the U.S., for example, President Obama announced the High School Redesign initiatives in early 2013, which aim to better prepare students for the competitive nature of college and the workforce. More than $100 million was awarded to high schools that have set out to transform the structure of the classroom and school day to support more real world and competency-based learning through the creative integration of technology.[8]

Practice. Each of the six trends identified by the expert panel has numerous implications for teaching and learning practice, and in many cases, current examples are easy to find. A widespread emphasis on integrating deeper learning approaches in the form of project-based and hands-on learning has already spurred more real world opportunities for students. For example, at Career Path High, students are exposed to college through learning activities that take place on the campus of Davis Applied Technology College. The school uses a competency-based model that encourages students to choose their own learning paths.[9]

As gesture-based technology has become commonplace for consumers, more intuitive devices are being incorporated into learning. Though the mainstream use of touch and motion-based technologies are considered to be at least five years away, some classrooms are taking a cue from the entertainment industry to foster more interactive learning. A teacher at Sunset Elementary School in Colorado has discussed her experiences using the Microsoft Kinect gaming system in her first grade classroom for a range of subjects, including geography and science, and noted improved student engagement.[10]

The following pages provide a discussion of each of the trends highlighted by this year's expert panel that includes an overview of the trend, its implications, and curated recommendations for further reading on the topic.

Rethinking the Roles of Teachers

Fast Trend: Driving educational technology adoption in schools over the next one to two years

Teachers are increasingly expected to be adept at a variety of technology-based and other approaches for content delivery, learner support, and assessment; to collaborate with other teachers both inside and outside their schools; to routinely use digital strategies in their work with students; to act as guides and mentors to promote student-centered learning; and to organize their own work and comply with administrative documentation and reporting requirements. Students, along with their families, add to these expectations through their own use of technology to socialize, organize, and informally learn on a daily basis. The integration of technology into everyday life is causing many educational thought leaders to argue that schools should be providing ways for students to continue to engage in learning activities, formal and informal, beyond the traditional school day. As this trend gathers steam, many schools across the world are rethinking the primary responsibilities of teachers. Related to these evolving expectations are changes in the ways teachers engage in their own continuing professional development, much of which involves social media and online tools and resources. While fully online schools are still relatively rare, an increasing number of teachers are using more hybrid and experiential learning exercises, and experimenting with social media and other ways of building learning communities.

Overview

As schools make the shift to more student-centered learning, they are also faced, as a matter of course, with rethinking the functions of teachers. In ideal situations, the teacher's role is becoming that of a mentor, visiting with groups and individual learners during class to help guide them, while allowing them to have more of a say in their own learning. This trend has led to a number of regional and global efforts to aggregate best practices and create new resources for the 21st century teacher. UNESCO Bangkok, for example, launched the "ICT in Education" initiative to explore and promote ways for teachers to harness technology and adapt their roles in the classroom.[11] Their website highlights a number of capacity-building projects across the world, such as eTwinning, an online community and collaboration space for schools across Europe.[12] Increasing pressure is being placed on teachers not only to understand how to use these types of tools, but also to integrate them in ways that foster more authentic and digital learning.

Greater accessibility to the Internet also continues to spark profound changes in traditional paradigms. Teachers are no longer the primary sources of information and knowledge for students when a quick web search is at their fingertips. Instead it is up to teachers to reinforce the habits and discipline that shape life-long learners — to ultimately foster the kind of curiosity that would compel their students to continue beyond an Internet search and dig deeper into the subject matter. In early 2014, a group of CEOs penned an open letter to the chairman of the United States Federal Communications Commission to loosen restrictions on Internet usage in schools and increase connectivity,[13] a sentiment that reflects an attitude shift on how the web is valued for learning. In order to be prepared to guide learners to effectively use the Internet, teachers are increasingly expected to be knowledgeable on the practices, skills, and resources that will be useful to students as they continue their education and seek gainful employment.

One visible example of the transformation of teaching is the Recognizing Educational Success, Professional Excellence, and Collaborative Teaching (RESPECT) project, an educator-led initiative in the U.S. that aims to better prepare students for the 21st century workforce.[14] As part of this effort, the Department of Education has released a blueprint to guide teachers in adapting their pedagogies and approaches through continued professional development, and cultivating an environment of shared responsibility. The blueprint also calls for more competitive salaries for teachers to attract more talent into the education sector.[15] Universities are also working to evolve the teaching practice by providing K-12 classes with entrepreneurial experiences. For example, the University of Iowa's Jacobson Institute for Youth Entrepreneurship trains teachers to integrate business and innovation-driven curricula that will foster more critical thinking and problem-solving among students.[16] Incorporating entrepreneurship in education provides a foundation for the kind of training that will be necessary for teachers as technology brings new forms of education to the forefront and highlights the importance of developing life-long learning strategies in the global economy.

Implications for Policy, Leadership, or Practice

Key to nurturing the new role of teachers is providing them with plentiful opportunities for professional development. Singapore offers a noteworthy model in which every teacher is entitled to 100 hours of training per year, and each school has a special fund allocated to supporting these learning opportunities.[17] The Academy of Singapore Teachers Center was also built by the Ministry of Education primarily as a hub for teachers to regularly gain new skills and convene to share best practices.[18] For educators in other parts of the world, a number of online platforms have been developed recently to equip teachers with technical skills without the expense of traveling, including the international NMC Academy,[19] along with EdTech Leaders Online, which focuses on aligning teaching practices with the Common Core.[20]

Part of finding success in this changing landscape is determining the right balance in how class time is used, which is one of the underlying notions of a teaching model that is gaining momentum in schools — the flipped classroom. Rather than the teacher using class time to lecture and dispense information, that work is done by each student after class, and could take the form of collaborating with their peers in online communities, curating online content, watching video lectures, listening to podcasts, and more. The flipped classroom is gaining momentum in every region, particularly in Europe where the European Commission's Creative Classrooms Lab recently held the Policy Makers Workshop in Brussels that focused on designing guidelines for the implementation of flipped classroom models. The resulting report, *Policy Maker Scenario: Flipped Classroom*, promotes a shift in practice to more student-controlled learning, which teachers can foster through the use of tablets and similar devices, apps for note-taking and content creation, and virtual learning environments.[21]

Across the world, many successful flipped classroom models are already well underway, including South Bend Career Academy, an independent charter school in Indiana that is in their third year of a flipped program. Students watch videos at home and then complete computer simulations during class to showcase what they have learned. A science teacher there describes his new function as a classroom guide and coach, walking around the room and having individual discussions with each student. Thirty classrooms across Stillwater, Minnesota also piloted a flipped classroom approach, where teachers felt their new roles enabled them to cover more content and parents noticed an improvement in their children's engagement and performance.[22]

For Further Reading

The following resources are recommended for those who wish to learn more about rethinking the roles of teachers:

Edcamps: Remixing Professional Development
go.nmc.org/profes
(Andrew Marcinek, *Edutopia*, 19 March 2014.) This article describes how professional development has evolved from a traditionally passive experience to a collaborative culture of shared learning. > *Practice*

How a Radical New Teaching Method Could Unleash a Generation of Geniuses
go.nmc.org/radical
(Joshua Davis, *WIRED*, 15 October 2013.) The author explores how a teacher in a rural town was able to improve student performance by implementing inquiry-based instruction techniques learned through videos on the Internet. > *Practice*

Moving Education into the Digital Age: the Contribution of Teachers' Professional Development
go.nmc.org/moving
(P. Twining et al., *Journal of Computer Assisted Learning*, 3 June 2013.) Research indicates that effective models of teacher education require changes at several levels of educational systems, and that technology presents an opportunity to introduce new structures and roles that support these changes. > *Practice*

Supporting Teacher Competence Development for Better Learning Outcomes
go.nmc.org/support
(European Commission, July 2013.) The recommendations in this report are the result of a peer-learning process between experts on teacher education nominated by 26 countries and by European bodies of stakeholders that drew shared conclusions about how to implement effective policies. > *Policy*

Towards Teacher-Led Design Inquiry of Learning
go.nmc.org/inqui
(Valerie Emin-Martinez et al., The Open University, 2014.) This paper proposes teacher-led design inquiry of learning as a new model of educational practice and professional development that integrates teacher inquiry into student learning, learning design, and learning analytics. > *Leadership*

The Uncomfortable Truth About Personalized Learning
go.nmc.org/plearn
(Stephen Laster, *Gigaom*, 2 September 2013.) The Chief Digital Officer at McGraw Hill-Education lists the three skills modern teachers should have in order to take advantage of personalized learning. > *Practice*

Shift to Deeper Learning Approaches

Fast Trend: Driving educational technology adoption in schools over the next one to two years

There is a new emphasis in the classroom on deeper learning approaches, defined by the Alliance for Excellent Education as the delivery of rich core content to students in innovative ways that allow them to learn and then apply what they have learned.[23] Project-based learning, problem-based learning, inquiry-based learning, challenge-based learning, and similar methods foster more active learning experiences, both inside and outside the classroom. As technologies such as tablets and smartphones are more readily accepted in schools, educators are leveraging these tools, which students already use, to connect the curriculum with real life applications. These active learning approaches are decidedly more student-centered, allowing learners to take control of how they engage with a subject and to brainstorm and implement solutions to pressing local and global problems. The hope is that if learners can connect the course material with their own lives and their surrounding communities, then they will become more excited to learn and immerse themselves in the subject matter.

Overview

Many experts believe that learning by creating and doing will engage students in their education, prepare them for success in college and careers, and, perhaps most importantly, develop a propensity for problem solving that will endure throughout their lifetime.[24] Deeper learning is a term increasingly used to describe a variety of approaches in which students gain knowledge and skills by investigating and responding to a complex question, problem or challenge. (For an in-depth example, see the topic on Creating Authentic Learning Opportunities in the Challenges section of this report.) By working on self-directed projects where students think critically and communicate effectively, students are mastering core academic content aligned with 21st century skills while tackling real issues in their community and beyond. Deeper learning can be an important approach to making schools more relevant and effective, and this trend is gaining traction across the world. Malaysia, for example has created a National Education Blueprint for 2013-2025 that seeks to transform the nation's schools by developing young Malaysians into knowledgeable and creative critical thinkers who have the leadership and communication skills to succeed in the 21st century. [25]

A major component of this trend is the rise of students who are learning important lessons by creating projects, products, and services that directly benefit the world around them. For example, eighth-graders at The Option Program at Seward, a Seattle alternative public school, are learning about their community by volunteering at local social-service organizations. Similarly, a school initiative called Quest2Matter called for students across Pennsylvania to devise strategies for solving both local and global challenges — well over 100 quests were submitted, including plans for suicide prevention and ideas for bringing live music performances to schools without programs for the arts.[26] The goal for these types of experiences is for students to learn by doing, and for them to understand that they can effect positive change on the world, even as students. While deeper learning is taking place informally at after-school programs and through extracurricular activities, more school leaders are recognizing its value in formal settings. At Da Vinci Schools in California, for example, students now learn on-the-job skills in work experience programs.[27]

To enable the shift to deeper learning, schools are thinking about how they can leverage technology to produce products and extend the learning experience beyond the classroom. Challenge-based learning, another thread of deeper learning, is defined by Apple as an engaging multidisciplinary approach to teaching and learning that encourages learners to apply the technology they use in their daily lives to solve real-world problems.[28] Students at Holy Family East Granville K-6 school in Australia use iPads loaded with Garage Band and iMovie to create movies and record interviews with police officers, CEOs, and politicians for their 24-hour Internet news station called HFSTV.[29] The interviews bring to light community issues, including texting and driving, that the students then try to solve by producing and selling products such as car safety signs.

Implications for Policy, Leadership, or Practice

Work is well underway across the world to develop policies to encourage deeper learning approaches in schools. To promote economic development in Europe,

the European Commission released *Work-based Learning in Europe: Practices and Policy Pointers*, a report aimed at producing policy guidance informed by practice examples from member states for policymakers and practitioners.[30] In the U.S., the Common Core Standards were developed to provide clear and consistent learning goals to help prepare students for life beyond school. The standards demonstrate what students are expected to learn at each grade level, based on the application of higher order thinking skills and preparing students for success in the global economy and society.[31]

Education leaders are working together to develop more professional development opportunities for teachers so they can integrate deeper learning in the classroom. The Alliance for Excellent Education,[32] the Buck Institute for Education,[33] and the Hewlett Foundation[34] are just a few groups leading efforts to work with states and districts to improve learning goals, provide teachers with ongoing training and tools, and share best practices from exemplary schools. Expedition Learning, a Hewlett Foundation grantee, develops curriculum, lesson plans, and training opportunities for educators.[35] Education leaders can use this growing body of resources to promote the value of deeper learning and bolster the integration of this approach in schools.

Innovative approaches to deeper learning have spread across the U.S., changing the traditional classroom experience. Competencey-based learning models, another type of deep learning approach, where students gain credit for proving the mastery of competencies rather than the traditional time-based model of instruction, have grown increasingly popular over the past few years.[36] Career Path High students, for example, are immersed simultaneously in a high school completion track while experiencing a college environment on the campus of Davis Applied Technology College. Students have the flexibility to work at home, remotely, and to use the on-site facilities with a competency-based model allowing maximum flexibility to work on their own path and at their own pace.[37]

For Further Reading

The following resources are recommended for those who wish to learn more about the shift to deeper learning approaches:

Developing Assessments of Deeper Learning: The Costs and Benefits of Using Tests that Help Students Learn
go.nmc.org/assessm
(Stanford Center for Opportunity Policy in Education, 2013.) This paper urges policy makers to focus on evolving testing so that it measures deeper learning and college and career readiness, instead of the current state tests which focus on multiple-choice questions and only measure low-level thinking skills. > *Policy*

Portland Maine Problem Solvers
go.nmc.org/portmaine
(Lauren Parent, *Expeditionary Learning*, 25 November 2013.) King Middle School in Maine uses an approach called "expeditionary learning" that gives students a challenge to solve in which they must creatively invent, design, and engineer their solutions. The goal is for students to develop confidence, communication skills, and other life skills. > *Practice*

Project-Based Learning Toolkit
go.nmc.org/pbltoolk
(Digital Learning Day, accessed 15 May 2014.) The Alliance for Excellent Education created a project-based learning toolkit that includes frameworks for approaching PBL and specific project plans that address standards, 21st century skills, and options for various technologies and lengths of implementation. > *Leadership*

Smart List: 10 Innovative High Schools, 10 Deeper Learning Networks
go.nmc.org/teninn
(*Getting Smart*, 18 August 2013.) This list of innovative high schools and deeper learning networks provides examples of actions that high schools are taking to prepare their students for the quickly changing world they will enter upon graduation. > *Practice*

State Education Standard on Deeper Learning
go.nmc.org/nasbe
(NASBE.org, accessed 15 May 2014.) Articles from the National Association of State Boards of Education explore a range of topics around deeper learning, including the need for systemic changes for deeper learning, assessments for deeper learning, examples of schools implementing deeper learning, and the findings and recommendations of NASBE's 2013 "Study Group on Deeper Learning." > *Policy*

Time for Deeper Learning: Lessons from Five High Schools
go.nmc.org/timeand
(Kathleen Traphagen, National Center on Time & Learning, Spring 2013.) This report focuses on a condition that must be apparent to facilitate deep learning, which is allocating sufficient time to activities and lessons that foster it. The five schools that the National Center on Time & Learning examines have each received support from the Hewlett Foundation for their dedication to deep learning. > *Practice*

Increasing Focus on Open Educational Resources

Mid-Range Trend: Driving educational technology adoption in schools within three to five years

Open educational resources (OER) are growing in breadth and quality, as is the use of these materials in classrooms, networks, and school communities world wide. The use and adoption of OER materials is increasingly a matter of policy in schools, especially in the many disciplines in which high quality educational content is more abundant than ever. Understanding that the term "open" is a multifaceted concept is essential to following this trend; too often it is mistaken to mean simply "free of charge." Advocates of OER have worked towards a common vision that defines it more broadly — not just free in economic terms, but also in terms of ownership and usage rights. Open content uses Creative Commons and other forms of alternative licensing to encourage not only the sharing of information, but the sharing of pedagogies and experiences as well. The goal is that OER materials are freely copiable, freely remixable, and free of barriers to access, cultural sensitivities, sharing, and educational use.

Overview

The notion of sharing is inherent to the philosophy of open content, and in 2002, the non-profit organization Creative Commons began to address the need for alternative licensing so that people could legally share and adapt creative works. The result was a set of content licenses that fulfilled the void between "all rights reserved" and no rights at all. The *NMC Horizon Report* series itself is published under a Creative Commons 4.0 Attribution License, which allows readers to repurpose, remix, and adapt the reports freely, as long as the source and authors are cited. With the vision of realizing the full potential of the Internet through maximizing digital creativity and sharing, the Creative Commons offers six legal licenses that are easy to understand by the common person and can be embedded into Web resources and identified by search engines.

Resolving intellectual property issues has been crucial to supporting the movement toward OER. To this aim, the CK-12 Foundation has created the only free, web-based application for adapting open source educational material and creating customized textbooks that are adaptable for anyone and for any purpose. All CK-12 materials fall under the Creative Commons BY-NC license, including digital resources created by teachers using the FlexBook textbook creator, a free authoring tool. Currently, more than 38,000 schools in the United States are using CK-12 tools and materials, and the Foundation is increasing their impact internationally.[38] In 2013, the non-profit partnered with Datawind, the company that produces the affordable Aakash tablet, with the goal of providing free high quality math and science materials for primary and secondary schools in India.[39]

In this landscape, open textbooks for K-12 schools have emerged as a response to both the rising costs of traditionally published resources and the related lack of educational resources in some regions. While initiatives in higher education such as Boundless and OpenStax College have demonstrated promise for the creation and acceptance of high-quality open textbooks, equally credible sources for OER are not as prevalent for K-12 education.[40] According to iNACOL's 2013 *OER State Policy in K-12 Education* report, there are only eight states in the United States with policies that support the creation and dissemination of OER in school districts.[41] The report cites two main barriers to OER development for schools in the United States — lack of funding and oversight to support initiatives, and subsequent lack of resources for marketing and promoting OER.

Implications for Policy, Leadership, or Practice

Government leadership can support directives to create policies that acknowledge the potential of OER and allocate money specifically for its development. One region of the world that has made considerable advances toward the uptake of OER is Europe. In 2013, the EU identified the development of OER as one of three actions of the "Opening Up Education" initiative proposed to bring the digital revolution to schools and universities.[42] The initiative's related web portal is an expansion of an existing community that has been serving teachers since 2002, and it allows teachers, students, policy makers, and stakeholders to access existing European OER and forums where members exchange their experiences and ideas on OER practices, among other resources. Further, the EU has funded projects such as "Policies for OER Uptake" (POERUP), which has compiled a global inventory of over 300 national and large-scale OER initiatives to provide

policy advice about the use of OER across all education sectors.[43]

School leaders seeking to learn more about the impact of large-scale implementation of OER can look at state-wide and district-wide initiatives. Utah has been leading this front since 2012, when it announced its commitment to develop and support open textbooks to be used in schools and universities throughout the state. Utah is home to The Open High School of Utah (OHSU), an online public charter school founded on the premise that teachers and students must rely exclusively on OER for instructional content. Teachers at OHSU say the main benefit using OER is that it can create a customized experience for each learner, while saving time for the teacher; instead of delivering the same lecture to various classes, educators can repurpose their efforts to personalizing content for their learners and give them individualized attention when they need it. Moreover, OHSU administrators cite millions of dollars in savings for using OER compared to the cost of "leasing" content from corporate-providers that give access to educational materials for a defined period of time.[44]

Resolving intellectual property issues has been crucial to supporting the movement toward OER.

To aid teachers with integrating OER into their classroom practices, the OER Commons is an online hub for content curation and training that was developed by the Institute for the Study of Knowledge Management in Education.[45] The OER Commons provides teacher education on the use and creation of learning materials with Open Author, a three-step online publisher that licenses and shares the content with the OER Commons community.[46] In addition to offering face-to-face training sessions with the "Teachers as Makers Academy," the project also provides a year-long mentorship program and webinar trainings as part of the "OER Fellowship Program." OER Commons is a model for teacher education that transcends national boundaries and provides a variety of training options to teachers everywhere.[47]

For Further Reading

The following resources are recommended for those who wish to learn more about the increasing focus on open educational resources:

3 Practical Tips For Using Open Resources In Your Classroom
go.nmc.org/orclass
(Ariel Diaz, *Edudemic*, 26 April 2014.) Among other recommendations, the author acknowledges the importance of ensuring that the open educational resources chosen for a classroom reflect students' needs and preferences. > *Practice*

15 Steps for an OER Launch
go.nmc.org/byooer
(Adam Renfro, *Getting Smart*, 16 October 2013.) This article describes an OER campaign step-by-step and what to consider in initiating one. Digital OER content works hand-in-hand when students have access to the Internet through a 1:1 or BYOD initiative, but it can also supplement a classroom with limited resources as well. > *Practice*

Combining 1:1 and OER is an Educational Game Changer
go.nmc.org/gamech
(Michael Messner, *Emerging EdTech*, 1 September 2013.) The multimedia features of laptops, tablets, and smartphones alongside the wealth of educational videos, audio, and captioned slideshows available online are expanding the possibilities for teaching and learning while minimizing the need to purchase and set up cumbersome equipment. > *Leadership*

Illinois Open Educational Resources
go.nmc.org/ioer
(Open Educational Resources, accessed 12 May 2014.) Illinois Open Educational Resources provides users access to searchable, open, standards-aligned educational content to remix and personalize by saving and annotating to each user's learning library.
> *Leadership*

Open Education Europa
go.nmc.org/openup
(European Commission, accessed 12 May 2014.) The European Commission launched "Opening Up Education" to increase the use of publicly funded open educational resources in schools and universities and promote the acquisition of digital skills. > *Policy*

Open Educational Resources and Collaborative Content Development: A Practical Guide for State and School Leaders
go.nmc.org/practical
(TJ Bliss, DeLaina Tonks, Susan Patrick, iNACOL, 2013.) This guide describes how to create high-quality open content at scale and legally licensed, so they can be used across school, district, and state boundaries. > *Leadership*

Increasing Use of Hybrid Learning Designs

Mid-Range Trend: Driving educational technology adoption in schools within three to five years

As teachers and students alike become more familiar with and adept at using the Internet, classroom-based learning increasingly includes online learning components, hybrid learning strategies, and an increased focus on collaboration within and outside the classroom. Schools that are making use of hybrid learning models are finding that using both the physical and the virtual learning environments to their highest potentials allows teachers to further personalize the learning experience, engage students in a broader variety of ways, and even extend the learning day. Hybrid models, when designed and implemented effectively, enable students to use the school day for group work and project-based activities, while using the network to access readings, videos, and other learning materials on their own time, leveraging the best of both environments.

Overview

A renewed interest in online learning has taken place over the past few years, fueled in large part by press attention to massive open online courses (MOOCs), but also by increased access to the Internet and broadband services, and a growing recognition that online learning can indeed add value to almost any learning environment. Hybrid learning models, which blend the best of classroom instruction with the best of web-based delivery, place a strong emphasis on using school time for peer-to-peer collaboration and teacher-student interaction, while online environments are used for independent learning. Blended learning is often used as a synonym for hybrid learning, although several authors would distinguish between the two. For our purposes, we are using the term hybrid learning to encompass both perspectives. These hybrid models may require students to watch videos at home through platforms such as Khan Academy[48] or engage with other web-based content, while class time is repurposed as an opportunity for teachers to mentor individuals and groups, and for students to problem solve and work together with classmates. The distinction is in the degree to which the Internet components are woven into the curricular design.

The International Association for K-12 Online Learning's (iNACOL) latest survey of global online and blended learning initiatives shows the widespread growth of this digital strategy. The report concluded that elementary and secondary-level students living in North America, Western Europe, Asia, and Oceania have the most access to blended and online learning choices, and of the 23 reporting countries, only the Philippines had indicated no government funding for these types of initiatives.[49] While not part of national agendas yet, 24 states in the U.S. are experimenting with blended schools.[50] Although primarily an online instruction provider, the Florida Virtual School is partnering with the Christa McAuliffe Middle School to support a fresh blended learning approach. In this project, "Christa's Launch Pad," students sit on yoga balls and video game rockers while working through online United States history modules with the assistance of two classroom teachers.[51]

Forecasting the trajectory of blended learning, the Clayton Christensen Institute has published several papers describing the rise of blended learning in K-12 education. Their most recent paper, *Is Blended Learning Disruptive? An Introduction of the Theory of Hybrids*, explores blended learning through the lens of disruptive innovation theory to help anticipate the major shifts that traditional K-12 education will face in the coming years. Through this theoretical lens, hybrid learning is seen as a sustaining innovation that provides the best of online learning and traditional classroom instruction, but the researchers can see a time when value propositions like individualization, universal access and equity, and productivity become so effective that more disruptive models of blended learning will prevail over the traditional K-12 education experience.[52]

Implications for Policy, Leadership, or Practice

By categorizing hybrid learning as either sustaining or disrupting the traditional classroom, the Christensen Institute report provides school leaders with an underlying structure to consider as they gauge the effects of their efforts.[53] Education leaders with limited budgetary and architectural options, for example, can bolster the traditional classroom model for years to come by incorporating hybrid learning designs such as the rotational model where students alternate between one-on-one time with the teacher, individual and group work, and computer aided instruction. Leaders in charter

schools and others with more autonomy in budgetary matters contract with online learning providers, state policy leaders, philanthropists, and entrepreneurs to foster disruptive innovation. The report further recommends a series of steps to bolster disruptive innovation including focusing disruptive blended learning models initially in areas of non-consumption and committing to protecting a fledgling disruptive project.

In practice, hybrid learning is seen as a way to level the playing field for rural schools by providing more access to a variety of high-quality courses. The report *Transforming K-12 Rural Education through Blended Learning: Barriers and Promising Practices* surveyed rural teachers that took part in Idaho Learning Academy's professional development.[54] Teachers indicated that incorporating hybrid learning improved their ability to be innovative, monitor student learning, and enable greater one-on-one instruction. By allowing self-paced learning, teachers also reported positive correlations with quality of student work, interest level of students during instruction, and student perseverance. Additionally, teachers cautioned that hybrid learning projects take time and they recommended that teachers seek formal and informal training when possible.

To gain a global competitive advantage in mathematics, departments and ministries of education are examining the implications of hybrid learning for policy and practice.[55] The rotational design model was the focus of a U.S. Department of Education-funded study by the Rand Corporation. Using computer-based instruction called Cognitive Tutor Algebra I combined with textbook-based activities, students experienced an eight-percentile improvement over the control group in math scores in the second year of implementation.[56] While the study showed the efficacy of hybrid learning in improving math performance, more studies are needed to identify which specific components are most effective in order to drive policy.

For Further Reading

The following resources are recommended for those who wish to learn more about the increasing use of hybrid learning and related instructional designs:

Acting Secretary of Education Says Hybrid Learning Benefits Students
go.nmc.org/secr
(Pennsylvania Department of Education, 17 October 2013.) During the 2012-2013 school year, 15 Pennsylvania schools piloted hybrid learning in several classrooms. Results show that the participating schools met or exceeded program goals in academic performance, student engagement, parent confidence, and teacher satisfaction. > *Practice*

Blended Learning 101: Handbook
go.nmc.org/handb
(Aspire Public Schools, 22 July 2013.) Aspire Public Schools created this handbook to lay out blended learning models, best practices, case studies, online resources, and sample lessons to support implementation.
> *Leadership*

'Flexible' Classrooms: Blended Learning 2.0?
go.nmc.org/flexible
(Benjamin Herold, *Education Week*, 21 January 2014.) This article describes how the blended learning model used at Rocketship Mateo Sheedy Elementary in San Jose includes differentiated instruction, teacher collaboration, and integrated technology to cater to larger than average class sizes. > *Practice*

Innovation and Entrepreneurship in Education
go.nmc.org/newschoo
(Benjamin Riley, NewSchools Venture Fund, 16 May 2013.) The author describes how a Digital Depository of IT experts could bridge the gap between the federal government and schools so that federal education policy would have a direct effect of helping states and school districts build a digital infrastructure, allowing all students to have equal access to hybrid learning environments. > *Policy*

Is K–12 Blended Learning Disruptive? An Introduction of the Theory of Hybrids
go.nmc.org/christen
(Clayton M. Christensen et al., May 2013.) This paper from the Clayton Christensen Institute analyzes blended learning through the lens of disruptive innovation theory to help readers anticipate and plan for the likely effects of blended learning on the classrooms of today and schools of tomorrow. > *Leadership*

Transforming K-12 Rural Education through Blended Learning: Barriers and Promising Practices (PDF)
go.nmc.org/transforming
(iNACOL, October 2013) This paper helps explain the importance of systematic professional development and how teachers who used blended learning models were better able to support self-paced learning, provide resources to struggling students or those who missed class, obtain and use student achievement data, provide feedback to parents, and differentiate instruction.
> *Practice*

Rapid Acceleration of Intuitive Technology

Long-Range Trend: Driving educational technology adoption in schools in five or more years

Thanks to touchscreens and other natural user interfaces, today's students do not have to be technical experts to personalize their devices, manipulate content, and communicate and collaborate with others. It is already common to interact with devices entirely by using natural movements and gestures. Smartphones and tablets, Xbox Kinect, Nintendo Wii, the new class of "smart TVs," and a growing list of other devices built with natural user interfaces (NUIs) accept input in the form of taps, swipes, and other ways of touching; hand and arm motions; body movement; and increasingly, natural language. These are the first in a growing array of alternative input devices to recognize and interpret natural physical gestures as a means of interacting with computers. These intuitive technologies allow users to engage in virtual activities with movements similar to what they would use in the real world, manipulating content intuitively.

Overview

The idea of learners being able to have a completely natural interaction with their devices is not new, but neither has its full potential been realized. Natural user interfaces were largely popularized with the launch of the iPhone and its touchscreen in 2007, but discussions around the development of interfaces beyond command line interface and graphical user interface started in the 1970s and 80s when Steve Mann, widely regarded as the father of wearable computing, began experimenting with human-machine interactions.[57] From his work, the idea of natural user interfaces was born, along with the potential for scientists and designers to adapt this innovation to new technologies. What makes natural user interfaces especially appealing for teaching and learning is the burgeoning of high fidelity systems that understand gestures, facial expressions, and their nuances, as well as the convergence of gesture-sensing technology with voice recognition, which allows users to interact in an almost natural fashion, with gesture, expression, and voice communicating their intentions to devices.

Humans interacting with computers in a natural user interface are not always conscious of the framework because their gestures seamlessly influence their experience, mimicking the real world far more than an interface based on metaphors like commands and graphics. The appeal of this innovation is that a learner can experience information presented in a variety of modes without the distance that traditional interfaces impose; in other words, nothing gets in the way between the user and the information. Students have the opportunity to truly interact with the content. These types of NUIs can have profound effects on people within the realm of informal learning. For example, at museums, children using multi-touch walls and displays adapt to the mechanism quite naturally, which has increased support for using smartphones, tablets, and Microsoft Kinect for learning. At the Cleveland Museum of Art, the "Collection Wall" measures 40-feet wide, and its multi-touch technology enables patrons to move, select, and sort multimedia assets for open-ended exploration in a very intuitive manner.[58]

Although still a distance off from mainstream use, electrovibration reflects the next wave of this intuitive technology that could foster more authentic and experiential learning. Electrovibration refers to the process when a finger is dragged across a conductive, insulated surface, creating an electrostatic force that results in a rubbery, sticky, bumpy, or vibrating sensation. Applied to today's mobile devices, the phenomenon of electrically induced vibration is expected to herald the next evolution of touchscreen technology, offering the potential for students to feel the content or media they are viewing. Finnish company Senseg is at the forefront of applying this haptic technology to smartphones and tablets, and their electrovibration technology can be applied to any touch interface to create what they call "feel screens," where users can feel textures on the screen.[59] The future of "feel screen"-enhanced devices offers many possibilities for deeper interaction with educational content, and with it an accessibility that caters to users with physical and mental disabilities — making it a particularly exciting technology for K-12 special education.

Implications for Policy, Leadership, or Practice

This trend has already impacted practice in numerous schools across the world, particularly through the use of touchscreens. Auburn School District in Maine was one early adopter, equipping kindergarten students with

iPads for pre-reading and writing units. Being able to interact with the material on the screen improved letter and word recognition among students. In their pilot, the 129 students that were provided the iPads consistently performed better on tests than the 137 without them.[60] Similarly, the use of motion sensor-based systems such as Microsoft Kinect is enhancing teacher instruction, and the game element of this NUI has proven to motivate students. At Sunset Elementary School in Colorado, for example, a first-grade teacher incorporated Kinect in her classroom for lessons on animals, geography, and science, and she credits her learners' outstanding standardized test scores and improved student engagement to the use of the interactive learning tool.[61] Special education teachers at Steuart Weller Elementary School in Virginia are also leveraging "Kinect Adventures" to improve the social skills of students with Autism Spectrum Disorders; collaborating more intuitively through physical movements led to progress in their verbal communications.[62] Similarly, a physical education (PE) teacher reports using the Wii game "Just Dance" in class to help middle school students develop and interpret different rhythmic and movement skills.[63]

While there is no significant research showcasing school accidents related to this gesture-based technology, policy makers can contemplate developing guidelines for the safe and effective use of NUIs, especially as the technology advances and a heightened sense of touch and feel is involved. Much like how there are defined rules and regulations for school sports, incorporating elements of movement and physical interaction in non-PE classes require careful consideration.

As school leaders have acknowledged that NUIs in the form of gesture-based technologies are effective for learning, perhaps one of the largest areas of focus to accelerate this long-range trend lies in critical thinking around the next wave of intuitive devices. A noteable incarnation of speech-to-speech translation is automatic translation engines — several years ago, Microsoft Natural Language Processing engineers demonstrated software that can synthesize an individual's voice in another language, from English to Mandarin, in real time.[64] Progress in these machine learning technologies points to a world where students can connect to content — and each other — more effectively. Students in classrooms across the world can collaborate on projects with each other virtually. Additionally, emerging sensing technologies, like the electrovibration project "Revel" headed by Disney Research, could open up a whole new world of learning with the ability to understand the rich spatial dimensionality of an object through digital means.[65] Students would not need to go on field trips to explore and "touch" fossils, artworks, and other materials — or worry about damaging these simulated objects. There are opportunities for thought leaders to collaborate with research centers and companies to better understand how these technologies can be most effectively applied in schools, as well as to dream up new intuitive products that are specific to teaching and learning.

For Further Reading

The following resources are recommended for those who wish to learn more about the rapid acceleration of intuitive technology:

Beyond the GUI: It's Time for a Conversational User Interface
go.nmc.org/cuiwi
(Ron Kaplan, *WIRED*, 21 March 2013.) Ron Kaplan — a linguist, mathematician, and technologist — predicts the imminent emergence of the conversational user interface, which is based on voice-recognition and machine learning technologies. > *Practice*

Gesture-Based Computing Is Happening, Just Like Sci-Fi Said It Would
go.nmc.org/diz
(Adam Turner, stuff.co.nz, 22 April 2014.) Dizmo is a Kickstarter project to create a downloadable interactive web interface that will allow users to interact with widgets and apps in an intuitive Internet of Things operating system. When a user docks two widgets together on the Dizmo screen their functionality will integrate, i.e., stacking a weather app and thermostat gizmo together can set the heat to come on whenever the temperature drops below 60 degrees. > *Practice*

Interactive Virtual Reality In 3-D, The Newest Learning Tool
go.nmc.org/chaot
(Ariel Schwartz, *Fast Company*, 27 February 2014.) A company called Chaotic Moon has combined the Oculus Rift headset and the Leap Motion 3D gesture controller, creating an immersive way that students can learn about atoms and molecules by looking at the periodic table of elements in 3-D and manipulating hydrogen and oxygen atoms. > *Practice*

Project Envisions Teaching Fractions by Touch, Movement
go.nmc.org/fra
(Sean Cavanagh, *Education Week*, 6 February 2013.) Researchers at Teachers College are testing ways in which using natural user interface can help students ages 8 to 11 learn fractions. > *Leadership*

Rethinking How Schools Work

Long-Range Trend: Driving educational technology adoption in schools in five or more years

There is a focused movement to reinvent the traditional classroom paradigm and rearrange the entire school experience — a trend that is largely being driven by the influence of innovative learning approaches. Methods such as project- and challenge-based learning call for school structures that enable students to move from one learning activity to another more organically, removing the limitations of the traditional bell schedule. These novel arrangements encourage renovation of classroom layouts with the express focus of facilitating group interaction. Century-old practices in which students learn subject by subject while uniformly facing the front of the classroom are perceived by many as an antiquated approach to teaching and learning. The multidisciplinary nature of project-based learning and other contemporary approaches has brought attention to innovative designs of the school atmosphere that link each class and subject matter to one another. As learning becomes more fluid and student-centered, some teachers and administrators believe that schedules should be more flexible to allow opportunities for authentic learning to take place and ample room for independent study.

Overview

While the traditional model prevails in many classrooms, there are initiatives now that award funding to schools for their work toward innovative redesigns of the school day. Next Generation Learning Challenges (NGLC), for one, allocates funding for Breakthrough School Models, which put personalized learning first through flexible learning environments that leverage time, space, roles, and instructional modes to meet the needs of each student. Venture Academy, a charter school in Minneapolis, received seed funding from NGLC in 2013, based on their idea of designing a flexible model for students that eliminated math and reading classes while adjusting student schedules to accommodate technology courses and independent projects called Learning Quests. At Venture Academy, learning happens in a repurposed printing plant that contains no classrooms, but plenty of windows. Students' personalized learning pathways are guided by learning coaches, real-time assessment technologies, digital content, and emphasis on self-reflection.[66]

A radical approach to rearranging the school day can be seen in the Hellerup School in Denmark, a Danish school for grades 4-9 that is home to a model of teaching and learning that transcends traditional notions of classroom. A fair amount of learning takes place on the staircase located in the center of the building, according to Lisolette Nylander, the Deputy School Leader of the Hellerup School. Nylander explained that groups of students are organized by "Home Areas," where they meet for 15-20 minute lessons, and then are free to work individually or with groups in other spaces of the school. Teachers are expected to work in teams on lesson planning so that they are knowledgeable about the content for each level and can assist any students that need it. Nylander pointed out that this arrangement allows students to establish relationships with any of the teachers.[67]

Though this trend is at least five years away from mainstream implementation, there are certain schools that, after setting the precedent, are actively working to help other schools replicate progressive school structures through teacher education. High Tech High in San Diego, for example, is a public charter school that has embraced project-based learning as the cornerstone of instruction; the typical school day involves constant interactions between teachers and students as they work to design and execute ideas of real world value, such as building structures to protect marine life and producing informational DVDs to educate the public. With a solid foundation in project-based learning design, High Tech High offers three-day residencies throughout the year where teachers and administrators can observe the model in action. Afterward, the education continues via virtual meetings with High Tech High mentors and access to free materials on the charter school's website.[68]

Implications for Policy, Leadership, or Practice

Replacing the traditional paradigm of the school experience requires a consolidated vision of what 21st century schools look like so that national directives can support new ideas. In 2013, U.S. President Obama announced an initiative to rethink the high school experience with the goal of preparing students with relevant, real-world course work that would pave the way to college and then into the competitive workforce.[69] The High School Redesign initiatives granted $107 million

to promising schools that committed to strategically using learning time in more meaningful ways through rethinking school calendars, competency-based progression, and the effective use of technology.[70] Well-publicized national initiatives like this one offer financial support for school leaders with innovative approaches to the school day and the learning space.

Policy makers seeking to redesign the school experience can create guidelines to reflect the new conception to pass along to school leaders and practitioners. EU-funded research teams have already proposed a number of innovative designs for classrooms that reflect this reality. In *Future Classroom Lab Learning Zones*, six schemes are outlined and are intended to optimize physical space, leverage ICT resources, and address the changing teacher-student dynamic. Each scheme is centered on a specific skillset —Investigate, Present, Interact, Create, Exchange, and Develop — and is supported with a list of key objectives, useful equipment, and resources. The Develop layout, for example, emphasizes the idea that independent learning takes place at home, while the classroom is used for project work and collaborative activities. Thus, the school environment has learning spaces that are informal, relaxed places where learners can use their personal devices to access online resources and virtual learning environments in study corners and comfortable places, while tables and other common areas encourage face-to-face collaboration.[71]

Innovative learning environments call for teachers to have a solid grasp of the underlying pedagogies that support the use of technology in order to holistically transform the school experience. The OECD recently commissioned a study, *Technology-Rich Innovative Learning Environments*, which highlights the stages of integrating a new technology that lead to deep transformation of the teaching and learning experience. The report contains case studies to demonstrate that technology is a powerful way to restructure the learning environment. LUMIAR Schools in Sao Paulo, Brazil, for example, is presented as an innovative educational experience; through the use of technologies — the Mosaic learning platform, laptops, and interactive whiteboards — LUMIAR Schools fosters the individual building of competences and skills. There are no classrooms, and students work on various projects, documenting their efforts in ePortfolios, while Tutors and Masters (guides and subject matter experts, respectively) assist them on their learning paths.[72]

For Further Reading

The following resources are recommended for those who wish to learn more about rethinking how schools work:

The Future of Learning Environments
go.nmc.org/futurele
(Moa Dickmark, *Core 77*, 10 February 2014.) An architect explains how workshops in which students explore and question existing spaces at their school, as well as in their homes, can help better incorporate student feedback when designing their learning spaces and schools. > *Practice*

K-12 Breakthrough Models
go.nmc.org/nexgen
(Next Generation Learning, accessed 12 May 2014.) The Next Generation Learning Challenge developed by the Bill & Melinda Gates Foundation provides funding to schools implementing breakthrough models. Breakthrough models are entirely new or substantially transformed schools or degree programs, designed around each student to produce breakthroughs in student learning, high school graduation, and college completion. > *Leadership*

New Designs For New Schools
go.nmc.org/carneg
(Carnegie Corporation of New York, accessed 12 May 2014.) In this interview, Leah Hamilton, Program Director of Urban Education at Carnegie Corporation, discusses new designs for schools and priorities they must consider, such as making use of assets both in and out of school, including internships and service projects. > *Practice*

No Courses, No Classrooms, No Grades — Just Learning
go.nmc.org/nuvu
(Christina Farr, *MindShift*, 24 April 2014.) NuVu Studio is a project-based learning program in Cambridge, Massachusetts in which pedagogy is geared around multi-disciplinary, collaborative projects. > *Practice*

Summit Denali: Engaging Student-Centered High School Model
go.nmc.org/dena
(Tom Vander Ark, *Getting Smart*, 14 June 2013.) Summit Denali is a high school that is building its own competency-based, student-centered learning system. The college and career readiness system will track growth and trajectory of knowledge, skills, and success habits against college goals. > *Practice*

Why Do We Make Students Sit Still in Class?
go.nmc.org/hess
(Carolina Blatt-Gross, KRDO.com, 30 March 2014.) At Hess Academy, the focus is on giving learners an experiential education, sense of community, and flexibility that help them channel their inclination toward physical activity and movement. > *Practice*

Significant Challenges Impeding Educational Technology Adoption in Schools

The six challenges described on the following pages were selected by the project's expert panel in a series of Delphi-based cycles of discussion, refinement, and voting; the expert panel was in consensus that each is very likely to impede the adoption of one or more new technologies if unresolved. A complete record of the discussions and related materials were captured in the online work site used by the expert panel and archived at k12.wiki.nmc.org/Challenges.

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 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; and wicked challenges, the most difficult, are categorized as complex to even define, and thus require additional data and insights before solutions will even be possible. Once the list of challenges was identified, the "Upscaling Creative Classrooms" (CCR) framework, pictured in the executive summary, served as a lens to identify implications for policy, leadership, and practice.

As noted previously, the CCR Framework places learning environments, wherever they may occur, as part of an ecosystem that evolves over time, and is very responsive to the context and culture in which they reside. The eight-dimensional model, systemic by design, leads planners to consider all eight of the dimensions. In the context of this report, we underscore the notion that all of the topics here, if they are to be successful, will need schools and school systems to focus on all aspects of the model. We have chosen to highlight three meta-expressions of these dimensions in our discussions of each trend and challenge: policy, leadership, and practice.

Policy. While all of the identified challenges have important policy implications, two specific challenges are currently driving policy decisions in schools. According to the panel, the easiest of these to address is the development of and adoption of guidelines related to integrating more personalized learning in schools. The work to frame such policies is already well underway in the U.S. government, exemplified by the Department of Education's Race to the Top-District (RTT-D) grant program, in which personalized learning was a major focus in the development of individualized college and career readiness models for students. In this sense, personalized learning is increasingly viewed as a cornerstone of policies that promote education reform.[73]

Because not all challenges are of the same scope, the discussions here are sorted into three categories defined by the nature of the challenge.

Still a few years away from being solved is the challenge of keeping student data safe in an environment where their every movement and behavior can be exposed via the Internet and cloud-based services. The rise of learning analytics compounds this issue as schools are looking for ways to internally store and support student data. Though a number of privacy policies have already been established in the U.S., Australia, and Europe, cloud computing, especially when not used or understood well, still presents a minefield of safety concerns. SafeGov recommends the adoption of a regulatory approach to cloud computing to ensure data privacy in Europe, outlined in their report, *Protecting Vulnerable Data Subjects*.[74]

Leadership. Leadership implications are common to all the challenges described in this section, but two will require visionary leadership. The first is considered by the expert panel as a crucial need to incorporate more complex thinking and communication in learning experiences — skills that are vital for success in college and the workforce. Large-scale solutions are underway in Europe through the "Promoting Social Skills Amongst Students," in which leaders in five countries are designing educational materials that will specifically

hone students' emotional and social skills to improve their communication.[75]

The second opportunity for extraordinary leadership was deemed a wicked challenge by the expert panel. Schools are trying to understand how to keep formal education relevant to meet the needs of a rapidly evolving workforce and global society. In a school program developed in California called MathTrain.TV, students are in charge of an online video channel of math lessons that can be used by other teachers and students for classroom instruction. Middle school students are learning by directly contributing to the knowledge ecosystem while gaining critical technical skills.[76]

Practice. Each of the six challenges identified by the expert panel presents numerous impediments for advancing teaching and learning, and two in particular deserve mention here. Incorporating more authentic learning in curricula is classified as a solvable challenge, as it is already a priority for many schools across the world. At Clover Hill High School in Virginia, for example, history students have the opportunity to work with 3D printed replicas of Civil War-era wig curlers and pipes — items they would otherwise never be able to touch or hold.[77]

The second is classified as a wicked challenge. Many education leaders and theoreticians feel that emerging competition from new models of education is threatening confidence and attendance in brick-and-mortar schools. Some leaders view online learning as a way to increase equity and access for all learners. In the Netherlands, for example, many students with physical and mental disabilities are enrolled in the virtual Wereldschool.[78]

The following pages provide a discussion of each of the challenges highlighted by the expert panel that includes an overview of the challenge, its implications, and curated recommendations for further reading on the topic.

Creating Authentic Learning Opportunities

Solvable Challenge: Those that we understand and know how to solve

Authentic learning, especially that which brings real life experiences into the classroom, is still all too uncommon in schools. Authentic learning is seen as an umbrella for several important pedagogical strategies with great potential to increase the engagement of students seeking connections between the world as they know it exists outside of school, and their experiences in school. Use of learning strategies that incorporate real life experiences, technology, and tools that are already familiar to students, and interactions from community members are examples of approaches that can bring authentic learning into the classroom. Practices such as these may help retain students in school and prepare them for further education, careers, and citizenship in a way that traditional practices are too often failing to do.

Overview

Authentic learning, as defined by the EDUCAUSE Learning Initiative, typically focuses on real-world, complex problems and their solutions, using role-playing exercises, problem-based activities, case studies, and participation in virtual communities of practice. EDUCAUSE's report, *Authentic Learning for the 21st Century: An Overview*, suggests that authentic learning prepares students for the skills and knowledge demanded by universities and the workplace.[79] As the related topic on deeper learning (one approach to solving this challenge highlighted in the Trends section of this report) illustrates, experiential and hands-on learning curricula are growing increasingly popular in schools. Examples abound, which is why this challenge is seen as solvable — both its dimensions and its solutions are known. At the School of the Future in New York, for example, students mirror the work of scientists from the design process to the scientific assessment of their projects.[80] Establishing mutually beneficial relationships with businesses, organizations, and public entities in the community are promising avenues for development, and effective models are beginning to emerge. An increasing number of schools have forged these kinds of relationships.

While the concepts inherent in authentic learning are appropriate for a variety of disciplines, the need for authenticity is expressed most often in science, technology, and mathematics education. Through learning by doing in science, students gain the foundational skills, knowledge, and understanding of real scientists and technicians, as well as important related skills such as critical thinking, research and writing methods, and presentation techniques.

Virtual Enterprises International is an example of how authentic learning experiences can connect students with the world of business and entrepreneurship, preparing them for continuing their education and entering the workforce.[81] This in-school, global business simulation offers students project-based and collaborative learning, along with the development of 21st century skills in areas including problem-solving, communication, personal finance, and technology. Inspired by the Austrian model of apprenticeships, this experiential learning model engages students by replicating all the functions of real business in both structure and practice. Teacher-facilitators and business mentors guide students as they create and manage all facets of their virtual business from product development to marketing in a range of firms.

Implications for Policy, Leadership, or Practice

While educators are slowly embracing the concept of authentic learning, there is a need for more concrete policies that will stimulate the interest of schools and help guide them throughout the process — from standards for defining and evaluating authentic learning to establishing safety protocol for offsite learning experiences. Current examples of authentic learning in practice often involve initial vocational education, in which high school students are undertaking apprenticeships and shadowing professionals at local enterprises. The European Commission's report, *Work-Based Learning in Europe*, assesses the state of these programs and makes education and labor market policy recommendations to maximize their safety and effectiveness.[82] Among other suggestions, the report calls for investing in other types of work-based learning, including the development of onsite labs and workshops in schools that link back to the offsite vocational training.

In order to facilitate authentic learning in their classrooms, teachers continue to need adequate support to update their pedagogies and teaching materials.

The Common Core State Standards Initiative in the United States details what K-12 students should know in English language arts and mathematics, calling for more authentic learning assessments and projects. To support this initiative, Intel's Common Core Standards Toolkit offers resources to education leaders involved in planning and implementing authentic learning.[83] Similarly, ESTABLISH ("European Science and Technology in Action Building Links with Industry, Schools, and Home") is an international project in which policy makers, parent groups, and others are coming together to develop authentic learning experiences for secondary students, while providing education programs for teachers to help them incorporate this new curriculum in their classrooms.[84]

While initiatives such as Common Core State Standards and ESTABLISH convey an active interest from school leaders to implement authentic learning in STEM areas, more leadership is needed across all school disciplines. 3D printing, for example, is being viewed as a way to achieve more hands-on learning in the humanities, allowing students to explore cultural history through replicas of real-world artifacts. The Smithsonian Institution, the world's largest museum complex, recently launched a new 3D scanning and printing initiative. The project aims to open up access to museums' massive digital collections, so that schools can print historical objects for teaching and learning.[85] Similarly, members of the Virtual Curation Laboratory at Virginia Commonwealth University are seeing the educational benefits of 3D printing and modeling by creating special lesson plans for high school history classes. At a recent project at Clover Hill High School in Virginia, students had the opportunity to handle 3D printed replicas of Civil War-era wig curlers and pipes. High school students appreciated the historical value of the models and expressed deeper interest in learning more information about the items presented.[86]

For Further Reading

The following resources are recommended for those who wish to learn more about creating authentic learning opportunities:

Authentic Learning Experience at Crest Secondary School
go.nmc.org/crest
(School Bag, 9 December 2013.) At Crest Secondary School in Singapore, a vocational training program is closely integrated with the academic curriculum to enhance authentic learning for students. For example, students learn skills including how to assemble and fix a bicycle by exploring the mechanism of how bicycles work. > *Practice*

Creative Capitalists - Let's Make World A Better Place
go.nmc.org/ipmc
(IPMC 2013, accessed 12 May 2014.) The Innovative Product and Marketing Competition in India challenges students to critically examine their community, identify a problem, and try to solve that problem by creating an innovative product. In the process, students explore and integrate business concepts including marketing and presentation. > *Practice*

How Can Authentic Community Engagement be Fostered Through Federal Policy?
go.nmc.org/community
(Richard Gray, *Voices in Urban Education*, Spring 2013.) Districts and schools have to enter into new forms of public collaborations and partnerships with structures that encourage and support the active participation and ownership of parents, students, and community residents in the public education process. > *Policy*

How Technology Can Support Authentic Learning
go.nmc.org/cansupp
(Saomya Saxena, *EdTech Review*, 30 December 2013.) Authentic learning often relies on educational technologies to help develop scenarios that learners encounter in real-world settings. Online learning resources, communication tools, intelligent tutoring systems, concept mapping, immediate feedback, and recorded events are all beneficial tools to support creative projects, simulations, and reflection. > *Leadership*

HP LIFE e-Learning
go.nmc.org/hplifeelearning
(HP LIFE, accessed 15 May 2014.) HP Learning Initiative for Entrepreneurs (HP LIFE e-Learning) is a free, cloud-based online training program that helps teachers and students gain the business and IT skills they need to create or build their own businesses. It is also an adaptable OER that enriches curriculum in classrooms, training centers, and other settings as it facilitates participatory learning. > *Practice*

The inGenious Code: School - Industry Collaboration
go.nmc.org/inge
(Jean-Noel Colin et al., European Schoolnet, June 2013.) The inGenious code of conduct is Europe's first attempt to guide both schools and businesses in setting up alliances to show students how STEM subjects are applied in real world settings. > *Policy*

Integrating Personalized Learning

Solvable Challenge: Those that we understand and know how to solve

Personalized learning includes a wide variety of approaches to support self-directed and group-based learning that can be designed around each learner's goals. Solving this challenge means incorporating concepts such as personalized learning environments and networks, adaptive learning tools, and more into school activities. Using a growing set of free and simple resources, such as a collection of apps on a tablet, it is already quite easy to support one's ongoing social and professional learning and other activities with a collection of resources and tools that is always on hand. There are two paths of development for personalized learning: the first is organized by and for the learner, which includes apps, social media, and related software. School goals and interests are driving the other path, primarily in the form of adaptive learning. In this pathway, adaptive learning is enabled by intervention-focused machine intelligence that interprets data about how a student is learning and responds by changing the learning environment based on their needs. While the concept of personalized learning is fairly fluid, it is becoming clearer that it is individualized by design, different from person to person, and built around a vision of life-long learning.

Overview

The goal of integrating more personalized learning into schools is to enable students to learn with their own strategy and pace, and demonstrate their knowledge in a manner that is uniquely their own. Free or nearly free cloud computing tools, for example, allow users to create personalized learning environments, and easily store the content they want, share their content with others, gather new and relevant items, write personal commentary, complete assignments, and more. YouTube, iTunes U, Facebook, and other social media provide students with outlets to discover new content, disseminate their own, and develop digital portfolios they can carry with them and build upon throughout their schooling. At Point England School, for instance, students use Blogspot blogs as online portfolios to record their learning experiences and outcomes.[87]

This challenge is considered solvable because the underlying technologies needed to support personalized learning are readily available now.[88] For example, a student's smartphone or tablet and their collection of apps directly represents their assortment of interests. With hundreds of thousands of apps available in multiple marketplaces, it is easy to see how no two people are likely to share the exact same set. Everyone has distinctive preferences, and approaches learning and exploration differently; this is the basic premise of personalized learning. In many ways, Finland is perceived as a model for this trend, which is exemplified at Peltosaari School where ActiveInspire software and mobile devices are used to promote writing, photography, video and audio production, and other unique demonstrations of student knowledge acquisition. Though the term "personalized learning" may conjure images of students working alone, the school encourages collaborative activities in which students share ideas and create materials together, based on their learning similarities and differences.[89]

While many writers believe that Finland offers a number of useful frameworks,[90] educational researchers are also emphasizing the need for learning settings to be adaptable and flexible in order for personalized learning to take root.[91] Students' preferences and needs must be understood accurately before designing or implementing personalized learning activities. The goal is to give the student permission to make their learning as effective and efficient as possible, but adequate mentorship, especially at the K-12 level, is still a clear necessity. In this model, there is a need for teachers to adjust their roles in the classroom to focus less on dispensing information through lectures and more on being guides.

Implications for Policy, Leadership, or Practice

Personalized learning is, at its core, a way to allow students to pursue their education according to their individual needs. Some students, for example, may benefit from curating their own resource collections. The European Union's Responsive Open Learning Environments (ROLE) project took this approach in an effort to study the impact of student-created environments for personalized learning.[92] Resources including YouTube, Wikipedia, and Flickr were used to support teachers and students in developing open-source personal learning environments for their students. Over the four years

of the project, ROLE developed, tested, and deployed an operating learning environment and a collection of ROLE-designed widgets.

Adaptive learning software in the form of online learning platforms is an emerging area within the personalized learning space, but one that shows the potential of guiding students' individual progress through real-time formative assessment. These tools are envisioned as providing students and educators with tailored information about how lessons are progressing, with adjustments made on the fly as needed. Knewton provides online learning platforms that use such data to react and adapt to a student's behavior and performance.[93] Through predictive analytics and a recommendations engine, the application evaluates student proficiencies, factors in teacher- and student-indicated goals, and maps the relationships between learners and the content in order to determine the most appropriate pathways and priorities for each student.

There is already considerable consensus among government, policymakers, and school leaders of the importance of identifying methods of personalization that can be integrated into schools at scale. A 2013 report from the American Institute of Research, *Are Personalized Learning Environments the Next Wave of K–12 Education Reform?*, examines the U.S. Department of Education's Race to the Top-District (RTT-D) grant program, in which personalized learning was a major focus. The initial 16 grantees — awarded a total of $383 million — include 11 school districts, three charter agencies, and two consortia.[94] Through the RTT-D program, these institutions are developing blended learning environments, individualized college and career readiness plans, and competency-based models, which are all seen by the government as key to implementing effective personalized learning. As an example, grantee Carson City School District in Nevada is facilitating more individualized post-graduation preparation through career clusters that enable students to select and learn more deeply about the areas they are interested in, including business, agriculture, and information technology.

For Further Reading

The following resources are recommended for those who wish to learn more about integrating personalized learning:

At Colegio Montserrat, Pedagogical Innovation is a Never-Ending Process
go.nmc.org/cole
(Open Education Europa, 17 February 2014.) At Colegio Montserrat in Spain, every fourth year student is given their own iPad or laptop, which they use with the school's LMS, built on Moodle. This allows them to choose their own pathways through a learning landscape while their progress is charted in their personal e-portfolios. > *Practice*

How a District Ended Student Dropouts with Personalized Learning
go.nmc.org/taylor
(Roger Cook, *EdSurge*, 14 April 2014.) The Taylor County School District in Kentucky implemented individualized learning plans tailored to a student's interests and career path. Partnerships with universities, local enterprises, and businesses provide students with opportunities to pursue their professional curiosities. > *Practice*

Learning Menu Lets Students Personalize Class Requirements
go.nmc.org/menu
(Charlie Boss, *The Columbus Dispatch*, 20 January 2014.) At Hilliard Darby High School, a gamified learning menu allows students to choose from different options to reach their learning goals. Projects, including making a Powerpoint presentation or video, are worth more points than filling out a worksheet or writing a study. > *Practice*

Paths to Personalized Learning
go.nmc.org/southa
(Insync Creative Pty Ltd., March 2013.) Schools in South Australia's Mount Lofty Ranges region implement personalized learning programs that value classroom layouts designed to support flexible use of space, immediate access to a variety of learning materials, and ramping up student feedback. > *Practice*

Powerful Partnerships and Personalized Learning
go.nmc.org/hobs
(Claire Amos, *Teaching and e-Learning*, 11 February 2013.) Hobsonville Point Secondary School aims to cultivate each student's interests and passions into extended projects that shape their course of study. The deputy principal explains how an "unconference" environment would be beneficial in the classroom, allowing students to explore a range of topics through multiple perspectives of academics, entrepreneurs, and thinkers. > *Leadership*

What Personalized Learning Really Means for Modern Teachers
go.nmc.org/modern
(Jennifer Kelly, *Edudemic*, 4 August 2013.) An educator explains how personalization technologies can be used as an outlet for some learners to pursue their studies while others might benefit from other classroom activities. > *Practice*

Complex Thinking and Communication

Difficult Challenge: Those that we understand but for which solutions are elusive

It is essential for young people both to understand the networked world in which they are growing up and also — through complex thinking — to understand the difference between human and artificial intelligence, to learn how to use abstraction and decomposition when tackling complex tasks, and to deploy heuristic reasoning to complex problems.[95] The semantic web, big data, modeling technologies, and other innovations make new approaches to training learners in complex and systems thinking possible. Yet, mastering modes of complex thinking does not make an impact in isolation; communication skills must also be mastered for complex thinking to be applied meaningfully. Indeed, the most effective leaders are outstanding communicators with a high level of social intelligence; their capacity to connect people with other people, using technologies to collaborate and leveraging data to support their ideas, requires an ability to understand the bigger picture and to make appeals that are based on logic, data, and instinct.

Overview

While some aspects of this topic could be framed as similar to or overlapping with what several authors have described as "design thinking," for the purposes of this report, the two are considered as distinct concepts. The term "complex thinking" refers in this report to the ability to understand complexity, a skill that is needed to comprehend how systems work in order to solve problems.[96] Complex thinking could be described as an application of systems thinking, which is the capacity to decipher how individual components work together as part of a whole, dynamic unit that creates patterns over time.[97] Computational thinking, too, is related to the notion of complex thinking. Computational thinking entails logical analysis and organization of data; modeling, abstractions, and simulations; and identifying, testing, and implementing possible solutions.[98] Emphasis on these approaches in education helps learners understand how the world works and equips them with skills deemed essential in solving complex problems.

Another key skill is the ability to make complex ideas understandable, using data visualization, new forms of imagery, succinct narrative, and other communications techniques. In today's world, it is not enough to be able to conceptualize difficult challenges — one must also be able to make those ideas easy to grasp, easy to share, and easy to support. According to a 2013 Gallup poll, three out of four Americans polled believe that schools need to teach critical thinking and communication to children in K-12 education. This statistic aligns with what employers, educators, and students have expressed — young learners need skills to analyze information, communicate effectively, and collaborate in global environments to solve complex problems.[99]

Companies including Amazon, Google, and Facebook have been built on the insights of complex thinkers and communicators, who have popularized the use of big data to capture user-derived data in real-time, redefined the way we conceptualize consumer behavior, and have built an entirely new industry based on this work. While data mining skills can be applied across virtually any sector, schools are not yet adept at encouraging greater development of these aptitudes through complex thinking and communication. According to the European Commission's report, *Big Data: Analytics & Decision Making*, the market demand for big data is currently estimated at over €56 billion, and it is growing by 10% every year.[100] A recent report by business analytics provider, SAS, found that demand for data specialists is expected to rise by 243% over the next five years in the UK alone.[101] If data science is expected to become a major standard for decision-making, schools will be expected to shape learners who have complex thinking skills and can use data and visualizations to support their reasoning.

Implications for Policy, Leadership, or Practice

Policy makers around the world are developing initiatives that place complex and computational thinking at the forefront of national education agendas. In 2013, the Estonian government contracted Conrad Wolfram, the founder of computerbasedmath.org, to develop a math curriculum for secondary schools. By relying on computers, students would be able to focus on more real-world applications of math that require critical thinking rather than spending the time to learn mechanical functions that machines can do.[102] The effort was in conjunction with a national initiative put forth in 2012 to integrate coding into the curriculum starting in

the first grade. In a similar move, England implemented a national mandate that children be taught computer programming in primary and secondary schools. Comprised of four key stages, the goal is for students to finish their obligatory schooling with a comprehensive knowledge of Boolean logic and an understanding of how hardware and software work together to create computer systems that communicate with one another. By the time British students enter college, they will be able to build technologies, distinguishing them as digital leaders in the global marketplace.[103]

Leaders seeking to foster communication and social skills that will bolster applications of complex thinking can refer to programs that have already been scaled and proven effective. The EU-funded "Promoting Social Skills amongst Students" (PSS) project is a good example of a program that focuses on the development of emotional intelligence as a crucial indicator of success throughout school and life.[104] This initiative brought together institutions from five European countries — Bulgaria, Denmark, Italy, Poland, and the UK — with the intention of producing educational materials that promote effective communication skills such as understanding social cues, listening to the thoughts and feelings of others, and negotiating with others who have differing viewpoints. PSS created a guide with 60 lesson plans that reinforce social intelligence through games, discussion, and group tasks targeted at students ages 14 and up.

Practitioners will need to include more problem-solving and collaborative work at the classroom level to begin to address this challenge. Researchers from California State University are training K-12 educators in a new pedagogy that helps K-12 learners learn how to think and work like engineers. The emerging pedagogy, referred to as Computer Supported Collaborative Science (CSCS), supports Next Generation Science Standards (NGSS), which emphasize higher-order thinking skills not reinforced by traditional textbook centric instruction. The researchers underline the increasing presence of technology in schools as an opportunity to incorporate tools such as Google docs to facilitate a type of collaborative pedagogy that fosters the processes of scientific inquiry—asking questions and defining problems; developing and using models; planning and carrying out investigations; analyzing and interpreting data; using mathematics and computational thinking; and, constructing explanations and using evidence to communicate information.[105]

For Further Reading

The following resources are recommended for those who wish to learn more about complex thinking and communication:

Adding Coding to the Curriculum
go.nmc.org/adding
(Beth Gardner, *The New York Times*, 23 March 2014.) Estonia and England are among the growing list of countries worldwide implementing reforms that focus on teaching students to understand and create their own apps and devices. > *Policy*

Educators Call for Reform in How Programming is Taught in Schools
go.nmc.org/ref
(David Crookes, *The Independent*, 12 November 2013.) A Computer teacher at Our Lady's High School facilitates a series of workshops to introduce coding to young students, where discovery, failure, and questions are welcomed. > *Practice*

How Technology Has Changed Our Idea of 'Knowledge,' and What This Means for Schools
go.nmc.org/knowle
(Dennis Pierce, eSchoolNews, 30 July 2013.) The concept of knowledge has changed with the emergence of the Internet. The author discusses how organically growing online communities like reddit have proven that knowledge is no longer fixed, but constantly evolving. Students must now communicate and network as an integral part of the learning process. > *Practice*

New National Curriculum To Teach Five Year Olds Computer Programming
go.nmc.org/gove
(Steve McCaskill, *Tech Week Europe*, 8 July 2013.) England's Secretary of State for Education overhauled the curriculum to focus on teaching kids to create and debug simple programs with the aim of encouraging logical thinking, creativity, and interest in STEM. > *Policy*

Systems Thinking
go.nmc.org/systems
(Centre for Ecoliteracy, 2013.) This essay emphasizes the need for children to identify patterns in natural and social systems that will lead to greater understanding of sustainability issues. > *Practice*

Teaching Kids to Think Like Engineers
go.nmc.org/engi
(Breanna Draxler, *Discover Magazine*, December 2013.) A new suite of open-ended standards seeks to give students experience with engineering and technology by working together to solve problems. > *Leadership*

Safety of Student Data

Difficult Challenge: Those that we understand but for which solutions are elusive

Safety of student data has long been a concern in K-12 education, which is evident through legislation that has been passed to safeguard students and their personal data, such as the federal Family Educational Rights and Privacy Act in the United States.[106] As schools embrace ubiquitous technology, and more learning takes place online and in 1:1 settings, researchers see great potential to leverage these digital learning environments to mine data, which can be used to decipher trends in student behavior and create personalized software.[107] Schools around the world are adopting cloud computing to support adaptive learning, promote cost-savings, and encourage collaboration, but sometimes the safety of student data is threatened when third-party vendors provide low-cost software as a service in return for access to student data that they then profit from.[108]

Overview

While proponents of big data for education point to the potential of adaptive learning and informed policies to improve education, privacy breaches in cloud services have alarmed the general public about the transparency of privacy practices in commerce and education. Washington Post's revelation that the U.S. National Security Agency and Federal Bureau of Investigation extracted data from the central servers of leading Internet companies such as Microsoft, Google, and Facebook has brought greater awareness to the safety of personal data on third-party public clouds.[109] With more people concerned about sharing their data through social media sites and their mobile apps, initiatives that aim to aggregate massive sets of student data and then work with third-party providers and vendors to develop educational solutions are experiencing an unexpected backlash that has all but stalled progress in this area. Ensuring the security of student data is important, but solutions are complicated because it requires an orchestration of modernized government policies, updated third-party agreements, and most importantly, a greater awareness of the issues.

Concern over student privacy has been illuminated recently through the example of Google Apps for Education, a popular public cloud used by schools across the world, when it came under fire for its policy regarding ad-serving to students. The company admitted that they scanned users' emails for ad-serving purposes even if the user chose to turn off ad-serving.[110] While these problems are not limited to Google, it is affecting how schools approach the integration of software as a service. Sweden's Data Inspection Board, for example, instructed the Rudbeck School in Stockholm to establish a new agreement with their cloud service provider to cover the protection and management of personal information or to cease using the service completely.[111] Schools are currently seeking cloud solutions that have tighter security measures, as was the case with the Houston Independent School District's selection of a third-party vendor[112] and the state of Illinois's move to a unified cloud.[113]

Recent studies are serving to create awareness about the current state of student data safety with the goal of formulating sets of recommendations. The report *Privacy and Cloud Computing in Public Schools* by Fordham University focused on how K-12 school districts addressed privacy when they transferred data to third-party cloud service providers.[114] The report revealed some sobering statistics around cloud computing in schools: while 95% of districts surveyed rely on cloud services, only 25% of districts inform parents on the use of cloud services, 20% of districts lack policies governing the use of online services, and fewer than 7% of contracts restrict the sale or marketing of student data by vendors. A SafeGov report conducted a similar survey on Australian parents' view of cloud services and online privacy and found that while most parents were not aware that data mining was happening in some schools, they overwhelmingly objected to the practice once informed — parents also believe that schools and government should create new regulations and voluntary opt-out policies. As politicians, education leaders, practitioners, parents, and students become more aware of how student data is being used and protected, cloud service providers must revisit data safety policies if they want schools to contract for their services.

Implications for Policy, Leadership, or Practice

Although laws such as the Family Educational Rights and Privacy and Children's Online Privacy Protection Acts in the United States, Data Protection Directive in Europe,

and Privacy Act in Australia already exist to ensure the safety of student data, some have not kept pace with the rapid development of technology.[115] Research groups are currently working to supplement gaps in these broad federal laws through policy recommendations at the state and local levels. The National School Boards Association's Council of Student Attorneys recently previewed a comprehensive policy guide which focuses on guiding districts and legal teams on how to ask the right questions and anticipate potential problems related to cloud computing and student privacy.[116] While cloud computing has gained traction in European schools, researchers there are still refining the safe and effective use of cloud computing. SafeGov, for example, suggests that a regulatory approach based on codes of conduct should safeguard students' privacy in Europe, and they list a call to action in their report *Protecting Vulnerable Data Subjects*.[117]

While cloud services lower costs, increase productivity, and encourage greater collaboration in schools, administrators are advised to take greater care in selecting third-party vendors by properly documenting all service agreements and by being more active in the negotiation of contract terms.[118] It is recommended that administrators also be transparent about privacy policies, establish implementation plans for the adoption of cloud services by teachers and staff, and establish data governance advisory councils.[119] In response to growing data safety concerns, the Consortium of School Networking (CoSN) recently partnered with Harvard University's Berkman Center for Internet and Society to develop a school district privacy toolkit as a professional development resource for educators.[120]

In order to ensure the safety of student data, teachers and students should be educated about how to select technologies and systems that are secure. The Fayette County Board of Education has created a webpage that hosts a variety of documents related to technology policies and procedures. Their table "Web 2.0 Tools, Ages, and Terms of Use" features some of the most widely used applications with information regarding terms of service, age limits, and parental permission requirements.[121] Teachers can also be proactive and inform their students about available resources to help make them more aware of their digital footprints as they explore the Internet. NetSmartz Workshop,[122] NetSmartzKids,[123] and PBS Kids Webonauts Internet Academy[124] are just a few of the websites teachers can use to inform students about how to stay safe while online.

For Further Reading

The following resources are recommended for those who wish to learn more about the safety of student data:

Cloud Computing, Regulatory Policy and Student Privacy
go.nmc.org/regulatory
(Steve Mutkoski, *Social Science Research Network*, 10 October 2013.) Many new education technology products and services are run by a third-party service provider as opposed to being run on servers operated by the school's IT staff, and many of the products or services often do not go through a more formal procurement process where regulatory compliance and other similar issues would be evaluated. > *Policy*

Maine Bill Would Ban Companies from Selling Student Data
go.nmc.org/maine
(Jessica Hall, *Portland Press Herald*, 5 March 2014.) This article describes a proposed bill aimed to protect student data such as names, email addresses, telephone numbers, or any unique identifiers from being sold or used for commercial purposes by providers of cloud computing services to Maine schools. > *Policy*

Top 5 Ways Schools Can Protect Student Privacy in the Digital Age
go.nmc.org/topfive
(Cameron Evans, *SmartBlog on Education*, 21 February 2013.) To ensure students' privacy and data are secured, this post recommends that schools understand their legal obligations, choose a technology vendor they trust, understand their vendor's privacy agreements, understand how their vendor will use student data, and educate faculty, students, and parents on appropriate activity. > *Practice*

UK School Opinions of Cloud Services and Student Privacy
go.nmc.org/ukop
(Ponemon Institute, 23 May 2013.) A study by SafeGov.org and Ponemon Institute reveals that as the migration to cloud services continues, UK schools, local councils, and education authorities, as well as the Department for Education, need to develop concrete measures to ensure that strong privacy protections for students and school staff are put in place. > *Leadership*

U.S. Education Department Issues Guidance on Student Data Privacy
go.nmc.org/edept
(Benjamin Herold, *Education Week*, 25 February 2014.) Seeking to help schools and districts better protect students' privacy, the U.S. Department of Education released best practices on the proper use, storage, and security of the massive amounts of data being generated by new, online educational resources. > *Policy*

Competition from New Models of Education

Wicked Challenge: Those that are complex to even define, much less address

New models of education are bringing unprecedented competition to schools, especially for students whose needs are not being well served by the current system. Charter and online schools have particularly gained traction in the United States, the United Kingdom, and Scandinavia. According to the National Alliance for Public Charter Schools, there are more than 6,000 charter schools in the U.S. alone with more than 1.9 million students enrolled, compared to over 98,000 public schools where 49.4 million students are enrolled.[125] Most states also offer and encourage enrollment in online courses, and some states are requiring that students complete them in order to graduate.[126] Adding to this challenge is the fact that many students do not formally attend either type of school; the National Center for Education Statistics reports that nearly 3% of the school-age population was homeschooled during the 2010-11 school year. Ninety-one percent of the parents of these children cited concern over the environments of traditional and charter schools when asked about their choice.[127] For school leaders and policy makers, the challenge is to meet such competition head on, offering high-quality alternatives to students who need them. As new platforms emerge, there is a growing need to frankly evaluate models and determine how to best support collaboration, interaction, deep learning experiences, and assessment at scale.

Overview

As a wicked challenge, the impact of alternative schooling on traditional institutions is multi-faceted. These new models often tout smaller classes, more personalized attention from teachers, and better access to high-caliber tools and technologies. While innovative new pedagogies and ways of thinking are challenging traditional paradigms, some pundits are concerned that the competition is not being fueled by the altruistic desires to improve learning experiences, but instead by where more money is being invested. Innovation Ohio, for example, analyzed data from the Ohio Department of Education and reported that in 2012, $774 million was deducted from public school budgets to fund charter schools across the state. Furthermore, over 40% of the state funding for charter schools was transferred from public districts that performed better than them on the Performance Index Score.[128] While this does not say that one model is superior to the other, it does reflect a shift in the way public schools are valued. Charter schools are often reported to foster more innovation, emphasizing authentic, project-based learning models and 1:1 technology programs, justifying greater monetary investments in the eyes of funders.[129]

New models of education also transcend the physical establishments and campuses. Online learning has gained momentum in higher education over the past decade, and similar efforts have been put into motion in K-12 to replicate the success. The Florida Virtual School, for example, is an entirely online public school where students across the state earn formal credit towards a diploma.[130] Florida, Michigan, and Alabama are now mandating that students take online courses as a requirement for high school graduation, citing college and career readiness as the primary reasoning.[131]

Movements such as "unschooling" are taking the idea of K-12 education in a completely different direction. Unschooling rejects conventional methods of learning and instead emphasizes education through natural means, such as gameplay, work experience, and household responsibilities, while encouraging the freedom for learners to pursue their personal interests.[132] While there are no concrete statistics that convey how many students are currently being unschooled, there is a growing crop of websites and online forums that demonstrate a burgeoning community of participants and supporters, such as Life Without School,[133] Unschoolery,[134] and Unschooling.com. Whether or not this model gains traction over the next five years, it is stimulating important conversations about the need to move to more progressive education paradigms that better engage all kinds of learners, even in traditional settings.

Implications for Policy, Leadership, or Practice

Policy makers and key thinkers across the world are aware of the demand for forward-thinking learning models. The Global Education Leaders' Program (GELP) is one such endeavor to foster more progressive pedagogies, curricula, and assessment methods with

the goal of increasing higher order thinking and skills within students.[135] Led by the Innovation Unit in the U.K. and sponsored by Cisco, The Bill and Melinda Gates Foundation, the Ellen Koshland Family Fund, and Promethean, GELP unites a group of policy makers, education system leaders, consultants, and other stakeholders with the common mission of transforming educational practices — regardless of whether the learning institution is public or charter. GELP teams have been deployed in participating countries and cities to influence change at the local, national, and international levels.[136]

In light of major initiatives that demonstrate the value of soft skills like collaboration and critical thinking for K-12 students, there is an opportunity for universities to expand the ways in which students can be admitted. In Australia, many admission councils at universities, such as Newcastle University[137] and University of Sydney,[138] have acceptance policies that include alternative entry from students who did not formally graduate from high school or are athletes with rigorous travel schedules but can demonstrate their knowledge through pre-college courses, tests, or other means.

Finally, there is a need for all models of education to take into account a variety of student needs. For example, some students simply cannot travel to brick-and-mortar institutions due to physical restrictions or disabilities. Online learning is increasingly being viewed as a vehicle for social equality, reaching disadvantaged students as well as those in rural areas. The "Bednet" in Belgium, for example, is an organization that serves children who are suffering from long-term and/or chronic illness.[139] Similarly, the Wereldschool in the Netherlands provides online, alternative education for students with special needs that may not be accommodated by the traditional school system.[140]

For Further Reading

The following resources are recommended for those who wish to learn more about competition from new models of education:

Are Personalized Learning Environments the Next Wave of K–12 Education Reform?
go.nmc.org/wave
(Courtney Tanenbaum, et. al, American Institutes for Research, August 2013.) This paper highlights takeaways from the U.S. Department of Education's Race to the Top-District, which scale teaching and learning innovations through personalized learning environments. > *Policy*

Career Path High
go.nmc.org/career
(Career Path High, accessed 12 May 2014.) Career Path High students are immersed simultaneously in a high school completion track while experiencing a college environment on the campus of Davis Applied Technology College. Students have the flexibility to work at home, remotely, and to use the on-site facilities with a competency-based model. > *Practice*

Charters, Public Schools and a Chasm Between
go.nmc.org/chasm
(Javier C. Hernandez, *The New York Times*, 11 May 2014.) Charter schools serve about 5 % of public-school students nationwide, according to the National Alliance for Public Charter Schools. This has created a competitive environment between charter schools and traditional schools that stifles the collaboration that should exist between the two school models. > *Leadership*

Massie: The Changing Landscape in K-12 Education
go.nmc.org/changem
(Jimmie Massie, *Richmond Times-Dispatch*, 26 January 2014.) The evolving business model in K-12 education is state and local governments, and the non-public sector, providing parents and students with a wide range of value-added choices for education in addition to the traditional local brick-and-mortar school. > *Practice*

Unschoolery
go.nmc.org/unsch
(Leo Babauta, 23 August 2014.) In the unschooling model, there is no curriculum, but instead students take authority, deciding exactly what they want to learn. Unschooling allows students to recognize that learning happens anywhere and everywhere and the keys are channeling curiosity, agency, and self-motivation.
> *Practice*

Unshackled and Unschooled: Free-Range Learning Movement Grows
go.nmc.org/unshackled
(Lorna Collier, *MindShift*, 2 May 2014.) Unschooling, a subset of the homeschooling community, is based on giving the student control over choosing what they want to learn rather than following a prescribed curriculum. The hope is that students will view life as a constant learning environment rather than separating school from the informal learning that takes place outside of any institution. > *Leadership*

Keeping Formal Education Relevant

Wicked Challenge: Those that are complex to even define, much less address

As online learning and free educational content become more pervasive, stakeholders and administrators must seriously consider what schools can provide that cannot be replicated by other sources. It is no longer necessary for parents to send their children to school for them to become knowledgeable and gain skills that will lead them to gainful employment. There are, however, valuable skills and attitudes that many believe can only be acquired in school settings. Generally speaking, trends in hiring make it clear that soft skills are differentiating outstanding applicants from the rest of the pack,[141] and are essential practices for solving problems in a world that is increasingly interconnected. Work ethic and the ability to persevere through tough challenges, both social and academic, are reinforced in formal education environments. While the goal of rethinking the value of education as a means of reinforcing attitudes and skills learners will need to seek credible information, work effectively in teams, and persist in achieving their goals is clear, the path to get there is much murkier.

Overview

Society's expectations about what skills students should learn in schools and how they should learn them are changing. The focus is drifting further away from traditional academics — language arts, mathematics, sciences, and social studies — toward the conception of more modern, interdisciplinary curricula that reflect real world work environments. As young people grow accustomed to using devices in their personal lives, more educators and school leaders are seeing that technology is essential for living, learning, and working in today's world. Validating informal learning experiences, too, plays a part in this challenge as students have more opportunities than ever to pursue their interests outside of the classroom. As schools aim to overhaul traditional practices, the underlying question is: toward what end?

At the heart of that question is understanding what attitudes students need to develop in their formative years. A number of school leaders have highlighted 'grit', understood as persistence and resilience, as the starting point of the conversation. A researcher from the University of Pennsylvania found that a person's grit is a better predictor of success than IQ. In other words, those who demonstrated a more determined attitude toward achieving their goals and interests were more successful than those with raw intelligence.[142] Teaching grit presents a new challenge; some educators believe the first step is replacing negative perceptions of failure with the understanding that mistakes are necessary for learning. Other teachers argue that telling children they are 'gifted' is an erroneous concept, and it is harmful in the long run. For these reasons, attitudes around 'grit' and determination are gaining support as key skills that will be relevant throughout a learner's informal and formal education.[143]

Discussions around 'grit' are also calling attention to other non-cognitive, social skills students should learn alongside the Common Core and other national standards. Schools such as Henry Ford Academy Elementary, a public charter school in Michigan, are prioritizing the development of soft skills such as empathy and the capacity to love. Coney Island Prep in Brooklyn has established a PRIDE system to promote professionalism, respect, integrity, determination, and ethics as a manner of reinforcing student integrity and character. In a *Huffington Post* commentary, a former high school math teacher and analyst for The New Teacher Project noted that his teaching had been evolving to help young people develop traits like curiosity, kindness, and other characteristics. At the same time, while promoting these values has enriched the culture of the school, teachers are challenged to accurately measure character growth and prioritize these skills when the focus on standardized test outcomes supersedes all else.[144]

Implications for Policy, Leadership, or Practice

Keeping education relevant means policy makers and key stakeholders must come to an agreement on what skills can or should be fostered in school environments. This requires an overarching vision that addresses the fundamental purpose of K-12 as it relates to the learner and their path from childhood to adulthood. The European Union has embraced the concept of the "life-long learner" since 2001, when it was defined broadly as all activities undertaken throughout life with the aim of improving knowledge, skills, and competence

within a personal, civic, social, and/or employment-related perspective. The notion that learning happens from pre-school years to post-retirement is integral to understanding European perspectives about the importance of education as it happens in formal, informal, and non-formal settings.[145] The focus on lifelong learning has driven the push for individualized learning pathways and generated attention around values that are necessary for social integration.

School leaders searching for ways to foster communication, collaboration, and critical-thinking skills have suggested both new approaches and the repurposing of familiar ones. Students at Lincoln Middle School in Santa Monica, California, for example, are constantly working on MathTrain.TV, an online video channel of math lessons that can be used for classroom instruction. Started by a 6th grade math teacher at Lincoln, the program is a method of engaging learners in creating content for other learners, and has been successful in helping students develop and use valuable technical and real world skills that they will be able to apply beyond the classroom.[146]

As teachers' roles become more multifaceted, their ability to manage social interactions in safe and productive ways is taking on more importance in the total school environment. The "Learning Positive Discipline" project is part of the Grundtvig Learning Partnership, an effort to address the kinds of behavior problems that may limit a student's ability to communicate and work with others effectively. Funded by the EU, the project has produced a guide, three modules of professional development, and an appendix of 50 positive discipline techniques. The goal is to help teachers facilitate conflict management and stimulate positive behaviors.[147]

For Further Reading

The following resources are recommended for those who wish to learn more about keeping formal education relevant:

Five Key Strategies to Get/Keep Kids Engaged at School
go.nmc.org/fivekids
(Valerie Strauss, *The Washington Post*, 29 October 2013.) This article describes how engaging students requires formative assessment, individualized and personalized learning, encouragement and praise for learning from mistakes, and flexible grouping. > *Practice*

The Great Promise of High School Redesign
go.nmc.org/promise
(Greg Miller, Educational Leadership in the 21st Century, 21 July 2013.) Over the past few years Alberta, Canada has made some bold moves to transform their education system so that it will produce young adults who are engaged thinkers and ethical citizens with an entrepreneurial spirit. > *Leadership*

Is 8th Grade Too Early to Pick a Career?
go.nmc.org/car
(Nancy Cook, *National Journal*, 14 May 2014.) The Education and Economic Development Act's Personal Pathways to Success program is designed to improve career development, workforce development, and economic development for South Carolinians through early career planning and an individualized curriculum. > *Policy*

Multiple Pathways Can Better Serve Students
go.nmc.org/muli
(Robert Schwartz, *Education Next*, Summer 2014.) The author argues that rather than let four-year colleges and universities exercise full influence over the high school curriculum, students should be given more pathways to future goals and careers by providing them with information, internship opportunities, and workplace exposure beginning in middle school. > *Practice*

Rethinking the 'Race Between Education and Technology' Thesis
go.nmc.org/race
(S. Craig Watkins, *DML Central*, 2 December 2013.) Access to technology does not mean access to the same forms of capital and opportunities to leverage technology in particular kinds of ways, including economic or educational opportunity. The author urges readers to focus on establishing alternative paths to opportunity and social mobility. > *Leadership*

Steinberg: Making High School Relevant is 'Top Focus'
go.nmc.org/topfocus
(Laurel Rosenhall, *The Sacramento Bee*, 28 October 2013.) California high schools could see an infusion of new programs that link academics with career exposure to provide students with a richer learning experience. A portion of the 2013-14 state budget will give high school a boost of relevancy by connecting students to the world of work. > *Practice*

Important Developments in Technology for K-12 Education

Each of the six developments in educational technology detailed in this section were selected by the project's expert panel using the Horizon Project's Delphi-based process of iterative rounds of study, discussion, and voting. In the NMC Horizon Project, educational technology is defined in a broad sense as tools and resources that are used to improve teaching, learning, and creative inquiry. While many of the technologies considered were not developed for the sole purpose of education, they have clear applications in the field.

The technologies, which the members of the expert panel agreed are very likely to drive technology planning and decision-making over the next five years, are sorted into three time-related categories — near-term technologies that are expected to achieve widespread adoption in one year or less; mid-term technologies that will take two to three years; and far-term technologies, which are forecasted to enter the mainstream of education within four to five years. Each technology topic opens with an overview of the topic and relates to areas of the CCR Framework as pictured in the executive summary.

The initial list of topics considered by the expert panel was arranged into categories that were based on the primary origin and use of the technology. The potential applications of the technologies featured, specifically in the context of global K-12 education, were considered in a series of online discussions that can be viewed at k12.wiki.nmc.org/Horizon+Topics.

The expert panel was provided with an extensive set of background materials when the project began that identified and documented a range of existing technologies used in both education and beyond. The panel was also encouraged to consider emerging technologies whose applications for schools may still be distant. A key criterion for the inclusion of a new technology in this edition was its potential relevance to teaching, learning, and creative inquiry in schools.

In the first round of voting, the expert group reduced the master set, shown on the next page, to 12 technologies that were then researched in much greater depth by the NMC staff. Each was then written up in the format of the Horizon Report and used to inform the final round of voting. Technologies that do not make the interim results or the final report are often thoroughly discussed on the project wiki at k12.wiki.nmc.org. Sometimes a candidate technology does not get voted in because the expert panel believes it is already in widespread use in schools, or, in other cases, they believe the technology is more than five years away from widespread adoption. Some technologies, while intriguing, do not have enough credible project examples to substantiate them.

There are currently seven categories of technologies, tools, and strategies for their use that the NMC monitors continuously. These are not a closed set, but rather are intended to provide a way to illustrate and organize emerging technologies into pathways of development that are or may be relevant to learning and creative inquiry. The list of seven categories has proven fairly consistent, but new technologies are added within these categories in almost every research cycle; others are merged or updated. Collectively, the categories serve as lenses for thinking about innovation; each is defined below.

> **Consumer technologies** are tools created for recreational and professional purposes and were not designed, at least initially, for educational use — though they may serve well as learning aids and be quite adaptable for use in schools. These technologies find their ways into schools because people are using them at home or in other settings.

> **Digital strategies** are not so much technologies as they are ways of using devices and software to enrich teaching and learning, whether inside or outside of the classroom. Effective digital strategies can be used in both formal and informal learning; what makes them interesting is that they transcend conventional ideas to create something that feels new, meaningful, and 21st century.

> **Enabling technologies** are those technologies that have the potential to transform what we expect of our devices and tools. The link to learning in this category is less easy to make, but this group of technologies is where substantive technological innovation begins to be visible. Enabling technologies expand the reach of our tools, make them more capable and useful, and often easier to use as well.

- **Internet technologies** include techniques and essential infrastructure that help to make the technologies underlying how we interact with the network more transparent, less obtrusive, and easier to use.
- **Learning technologies** include both tools and resources developed expressly for the education sector, as well as pathways of development that may include tools adapted from other purposes that are matched with strategies to make them useful for learning. These include technologies that are changing the landscape of learning, whether formal or informal, by making it more accessible and personalized.
- **Social media technologies** could have been subsumed under the consumer technology category, but they have become so ever-present and so widely used in every part of society that they have been elevated to their own category. As well established as social media is, it continues to evolve at a rapid pace, with new ideas, tools, and developments coming online constantly.
- **Visualization technologies** run the gamut from simple infographics to complex forms of visual data analysis. What they have in common is that they tap the brain's inherent ability to rapidly process visual information, identify patterns, and sense order in complex situations. These technologies are a growing cluster of tools and processes for mining large data sets, exploring dynamic processes, and generally making the complex simple.

The following pages provide a discussion of the six technologies highlighted by the 2014 Horizon Project K-12 Expert Panel, who agree that they have the potential to foster real changes in education, particularly in the development of progressive pedagogies and learning strategies; the organization of teachers' work; and the arrangement and delivery of content. As such, each section includes an overview of the technology; a discussion of its relevance to teaching, learning, or creative inquiry; and curated project examples and recommendations for further reading.

Consumer Technologies
- 3D Video
- Electronic Publishing
- Mobile Apps
- Quantified Self
- Tablet Computing
- Telepresence
- Wearable Technology

Digital Strategies
- Bring Your Own Device (BYOD)
- Flipped Classroom
- Games and Gamification
- Location Intelligence
- Makerspaces
- Preservation/Conservation Technologies

Internet Technologies
- Cloud Computing
- The Internet of Things
- Real-Time Translation
- Semantic Applications
- Single Sign-On
- Syndication Tools

Learning Technologies
- Badges/Microcredit
- Learning Analytics
- Massive Open Online Courses
- Mobile Learning
- Online Learning
- Open Content
- Open Licensing
- Virtual and Remote Laboratories

Social Media Technologies
- Collaborative Environments
- Collective Intelligence
- Crowdfunding
- Crowdsourcing
- Digital Identity
- Social Networks
- Tacit Intelligence

Visualization Technologies
- 3D Printing/Rapid Prototyping
- Augmented Reality
- Information Visualization
- Visual Data Analysis
- Volumetric and Holographic Displays

Enabling Technologies
- Affective Computing
- Cellular Networks
- Electrovibration
- Flexible Displays
- Geolocation
- Location-Based Services
- Machine Learning
- Mobile Broadband
- Natural User Interfaces
- Near Field Communication
- Next-Generation Batteries
- Open Hardware
- Speech-to-Speech Translation
- Statistical Machine Translation
- Virtual Assistants
- Wireless Power

Bring Your Own Device (BYOD)

Time-to-Adoption Horizon: One Year or Less

BYOD, also referred to as BYOT (Bring Your Own Technology), refers to the practice of people bringing their own laptops, tablets, smartphones, or other mobile devices with them to the learning or work environment. Intel coined the term in 2009, when the company observed that an increasing number of its employees were using their own devices and connecting them to the corporate network. Since implementing BYOD policies, the company has reported up to 5 million hours of annual productivity gains, a statistic that is compelling many other companies to consider BYOD.[148] In schools, the BYOD movement addresses the same reality; many students are entering the classroom with their own devices, which they use to connect to the school's network. While BYOD policies have been shown to reduce overall technology spending, they are gaining traction more so because they reflect the contemporary lifestyle and way of working. A 2013 Cisco Partner Network Study found that BYOD practices are becoming more common across industries, particularly in education; over 95% of educators surveyed responded that they use their own device for work purposes.[149] Although administrators and educators have cited IT security concerns, technology gap issues, and platform neutrality as challenges to the uptake of this technology, a growing number of models in practice are paving the way for BYOD to enter the mainstream.

Overview

The link between the use of personal devices and increases in productivity gets stronger each passing year as more organizations adopt BYOD policies. The integration of personal smartphones, tablets, and PCs into the workflow supports an on-the-go mentality, changing the nature of work and learning activities so that they can happen anywhere, at anytime. Employers and schools are finding that when given the opportunity to choose their device, users are saved from the effort and time needed to get accustomed to new devices and can therefore accomplish tasks with ease and efficiency. A recent study by Gartner predicted that by 2017, half of the world's employers will expect their employees to supply their own device for work.[150]

The success of BYOD aligns with global trends toward mobility as more people, from children to adults, own smartphones and are accessing the Internet in increasingly different environments. According to the report *ICT Facts and Figures 2014*, this year it is expected that the number of mobile-cellular subscriptions will approach the number of people on earth — almost seven billion.[151] Demand and use of mobile devices are advancing at a similar pace; Gartner predicts that in 2014, shipments of devices including PCs, tablets, ultramobiles, and mobile phones, will reach 2.5 billion units, with over three-quarters of those represented by mobile phones.[152]

Adoption of BYOD policy into the corporate sphere has provided a model for educational contexts, and the practice is gaining acceptance in schools all over the world. A recent survey of over 500 IT professionals from colleges, universities, and K-12 school districts across the UK and U.S. revealed that both teachers and students are using their own devices for "personal use." Likewise, more than half of the respondents stated that personal devices were being integrated into the classroom experiences. Similarly, a recent survey conducted by the Center for Digital Education and the National School Board Association found that uptake of BYOD in American schools has increased over 30% since last year's survey; currently, 56% of school districts are implementing BYOD programs.[153] Although not as widely implemented, schools in the UK as well are gradually taking note of BYOD's promise for teaching and learning. Funded in part by the Department of Education, the Open University developed and launched the Your Own Technology Survey in 2013 to determine how many UK schools and students are impacted by BYOD policies.[154]

Relevance for Teaching, Learning, or Creative Inquiry

For schools, BYOD is less about the devices and more about the personalized content that users have loaded onto them. Rarely do two devices share the same content or settings, and BYOD enables students and educators to leverage the tools that make them most efficient and productive. Devices have become the gateways to personal working and learning environments that facilitate the exploration of new subjects at a pace that is unique to each learner. This model ultimately gives learners ownership of their learning, as they are

entrusted to demonstrate their mastery of required competencies in methods of their choosing, and select the technological tools they need to do this. Education researchers highlight BYOD as the technology practice that will best accommodate this vision of personalized learning.[155]

BYOD has profound implications for primary and secondary education because it creates the conditions for student-centered learning to take place.

BYOD has profound implications for primary and secondary education because it creates the conditions for student-centered learning to take place. In 2013, Desert Sands Unified School District (DSUSD) in California adopted a BYOD approach and has taken advantage of the wireless, 1:1 learning environment to conduct formative assessment. Using an online grading system and an LCD projector, teachers can send questions to students' devices and monitor answers as they come in. This method of real-time assessment gives teachers the opportunity to adapt their instruction and review challenging concepts, and has been proven to drastically improve the performance of typically low performing students. Every student in DSUSD does their daily classroom activities on their personal Google Chromebook, which are purchased by their parents or donated to them through local, state, or federal grants.[156]

The use of personal computing devices (whether it be a laptop, tablet, or smartphone) in the classroom has been proven to foster a seamless learning experience in 1:1 situations. Researchers from the Hong Kong Institute of Education studied the effects of a BYOD model on sixth graders that were studying the anatomy of a fish using an inquiry-based approach. Using mobile apps including Edmodo, Evernote, and Skitch, students were able to take notes, snap photos, share their observations with classmates, and acquire knowledge that was beyond what was within the textbook. The researchers noted that the BYOD model gave students a sense of ownership and control over their learning, qualities that are absent from mobile learning studies where students use devices provided by the school. At the end of the study, it was concluded that BYOD in conjunction with an inquiry-based pedagogical practice had a positive impact on primary students' knowledge of the subject matter at hand.[157]

Bring Your Own Device in Practice

The following links provide examples of BYOD in use that have direct implications for K-12 education:

Belgrano Day School's BYOD Policy
go.nmc.org/bel
Argentina's Belgrano Day School's BYOD policy, standards, and guidelines for implementation are available on its website. They implemented BYOD to help students engage with an integrated curriculum and develop their digital literacy skills while solving real world problems. > *Policy*

BYOD at Ruyton Girls' School
go.nmc.org/melbo
Melbourne's Ruyton Girls' School has deployed a new IT network to support BYOD as part of the school's plan to access e-books and online course materials from Australia's Academic and Research Network. > *Practice*

Forsyth County Schools BYOT Strategy
go.nmc.org/fors
Forsyth County Schools has made their BYOT resources public so that interested schools can emulate their processes. Their website includes a wiki and way to sign up for BYOT tours to come to the school for a day and observe. > *Leadership*

For Further Reading

The following articles and resources are recommended for those who wish to learn more about BYOD:

6 BYOD Discussions Every School Should Have
go.nmc.org/discussions
(Vicki Davis, *Edutopia*, 4 February 2014.) These IT considerations can help schools plan to implement a BYOD infrastructure, covering topics that range from wireless printing to file syncing. > *Practice*

Mobile Devices in Education: Part One
go.nmc.org/ptone
(Mark Pearce, *Business Review Europe*, 1 June 2013.) The author analyzes the BYOD trend, citing specific lessons that education institutions can learn from businesses. He believes allowing students to use their own devices in class could give them a competitive edge. > *Leadership*

When Kids Craft BYOD Policies
go.nmc.org/kidscraft
(John Spencer, *Education Rethink*, 5 March 2013.) A teacher discusses how his sixth grade students created their own BYOD policy. He found that his students had very mature perspectives about mobile devices, equity, and responsibility. > *Policy*

Cloud Computing

Time-to-Adoption Horizon: One Year or Less

Cloud computing refers to expandable, on-demand services and tools that are served to the user via the Internet from specialized data centers and consume almost no local processing or storage resources. Cloud computing resources support collaboration, file storage, virtualization, and access to computing cycles, and the number of available applications that rely on cloud technologies has grown to the point that few education institutions do not make some use of the cloud, whether as a matter of policy or not. Over the past few years, cloud computing has been firmly established as an efficient way for businesses to protect data, develop applications, deliver software and online platforms, and to collaborate. Schools are deploying similar cloud-based strategies to boost collaboration, productivity, and mobility in teaching and learning.

Overview

Clouds, especially those supported by dedicated data centers, can be public, private, or a hybrid of these. Many institutions use software as a service (SaaS) and API services in the cloud to reduce IT overhead costs. Google Apps, for example, has become a popular choice for schools, and many have moved their email infrastructure to Gmail and adopted Google Drive for document sharing and collaboration. Whether learning takes place at home, work, school, on the road, or in social spaces, nearly every student who uses the network relies in some fashion on cloud computing to access or share their information and applications. Some are concerned, however, that many low-cost public cloud services may not meet national privacy and data protection standards and requirements for schools and students. Private cloud computing solves these issues by providing common cloud solutions in secure environments, and hybrid clouds provide the benefits of both types.

There is a consensus that cloud-based services provide a range of solutions related to infrastructure, software, and security. By means of virtualization, cloud computing providers can deliver fully-enabled virtual computing environments of almost any scale that can be accessed from any connected device, seamlessly, and on demand. Cloud services have also proven to cut the cost and time required for server maintenance, and offer support for new tools that foster best computing practices for easy sharing and mobility. They can negate the need for specialized IT staff that can be expensive and difficult to retain. Additionally, as the mobile Internet has expanded, an increasing number of tablets and other devices that are designed expressly to operate in the cloud have entered the market, and at price points that make them competitive for 1:1 computing and BYOD deployments.

The rapid integration of cloud computing into our everyday routines — from technology infrastructure to communication exchanges to the many apps and resources used for informal learning — has accelerated the interest in cloud computing for schools. As more individuals use cloud-based sharing services such as Dropbox and Google Drive in their personal lives, cloud computing has become widely recognized as a means of improving productivity and expanding collaboration in education. Numerous cloud computing projects are currently underway around the world, including examples such as Mashrek International School in Jordan,[158] the Government Girls School in the Cloud in India,[159] and the Ballerup Municipality cloud project in Denmark.[160]

Cloud computing has become widely recognized as a means of improving productivity and expanding collaboration in education.

Relevance for Teaching, Learning, or Creative Inquiry

A recent SafeGov.org study has revealed that the use of cloud services has grown rapidly over the past five years, making digital strategies such as BYOD, the flipped classroom, and personalized and collaborative learning environments fairly straightforward technologically.[161] The Fairfax County Public Schools in Virginia, for example, are using Google Apps for Education to promote communication, creativity, collaboration, and productivity among teachers and students.[162]

Students at the UK's King Solomon Academy are using Chromebooks, inexpensive laptops that rely on ubiquitous connectivity and cloud-based software and storage, for experiments with blended learning in a seventh grade math classroom.[163] The teacher has implemented a model where the core content is delivered via videos as homework, while other content and activities are delivered online. Access to the cloud is seen as a feature of Chromebooks, which are designed to work best with a persistent connection to the Internet.

While numerous cloud computing projects are currently underway around the world, privacy concerns noted earlier in this report have surfaced as key issues impeding more widespread implementation. The SafeGov.org report, *Protecting Vulnerable Data Subjects*, and Fordham University study, *Privacy and Cloud Computing in Public Schools*, offer lists of recommendations to data protection officials, schools and school authorities, parent associations, and cloud providers for establishing codes of conduct.[164] The aim is for these policies to ensure safe and effective use of cloud computing in schools.[165] School districts wanting greater control over privacy and costs should consider pooling resources to create infrastructures such as the illiniCloud, a statewide private cloud that offers Illinois's 869 school districts access to virtual servers, online storage, and high-speed network connectivity along with cutting-edge applications and important IT services such as disaster recovery.[166]

Cloud Computing in Practice

The following links provide examples of cloud computing in use that have direct implications for K-12 education:

3Tcloud computing in Zhejiang
go.nmc.org/zhuji
The city of Zhuji in Zhejiang has installed over 6,000 3Tcloud computing terminal devices in 118 schools in a project to replace all obsolete PCs in the city's school system with over 30,000 cloud terminal devices by 2015.
> *Practice*

Lansing Studies in the Cloud
go.nmc.org/lans
At Lansing Central School, a social studies teacher held online reviews for mid-term exams in the cloud using Google Hangouts and Google Docs to provide a private forum where students could study with each other.
> *Practice*

School on the Cloud
go.nmc.org/eusoc
The School on the Cloud partnership is an ICT network funded by the European Commission that works to evaluate future resources and scenarios for education in a cloud environment, then disseminate and expand best practices. It currently includes 18 countries. > *Leadership*

For Further Reading

The following articles and resources are recommended for those who wish to learn more about cloud computing:

Cloud Computing and K-12 Classrooms
go.nmc.org/cloudand
(Matthew Lynch, *The Huffington Post*, 8 December 2013.) A report by CDW Government found that over 40% of schools use cloud applications to store their data, and by 2016, schools are expected to spend 35% of IT budgets on the cloud. With these statistics in mind, the author provides examples of exactly how schools are using cloud services and the benefits they are experiencing.
> *Practice*

Cloud Service Providers and Key Issues for New Zealand Schools
go.nmc.org/netsafe
(Netsafe, accessed 15 April 2014.) Schools in New Zealand are responsible for making their own assessment of cloud services and their providers, but national software license agreements negotiated by the Ministry of Education are helping to ease the burden of carrying out a full technical assessment of a prospective cloud service. > *Policy*

What Is a Unified Cloud, and Why Are Schools Choosing to Build Them?
go.nmc.org/unified
(Wylie Wong, *EdTech Magazine*, 2 April 2013.) A unified cloud strategy at Indianapolis Public Schools integrates private and public cloud deployments, providing users with a centralized, web-based dashboard through which they can securely access email and the applications, files, reports, and other learning content that they need.
> *Leadership*

Games and Gamification

Time-to-Adoption Horizon: Two to Three Years

The culture around digital games is growing to encompass a substantial proportion of the world's population, with the age of the average gamer increasing every year. The gaming industry is producing a steady stream of games that continue to expand in their nature and impact — they can be artistic, social, and collaborative, with many allowing massive numbers of people from all over the world to participate simultaneously. A 2013 study by the American Psychological Association highlights the cognitive, motivational, emotional, and social impact video games have on human behavior; this significant body of research underlines the overwhelming potential of games to teach new forms of thought and behavior.[167] Studies like these are encouraging the uptake of games into the worlds of commerce, the military, and education, among others. Gamfication — the integration of gaming elements, mechanics, and frameworks into non-game situations and scenarios for training and motivational purposes — has added another level of complexity to discussions surrounding the potential of games to transform teaching and learning. Although still in its nascent stages in education, the gamification of learning environments is gaining support among educators who recognize that effectively designed games can stimulate large gains in engagement, productivity, creativity, and authentic learning.

Overview

Games and game-based learning have been featured in the K-12 Edition of the *NMC Horizon Report* series for the past several years, where they have remained just over the horizon, tantalizingly close, but still two to three years away. Gamification may be the new idea that moves this set of ideas and supporting technologies into broader use. The idea is to integrate game-like elements and mechanics, including quests, experience points, leader boards, milestones, and badging, among others, into non-game environments. A 2013 Accenture report highlighted the impact gamification will inevitably have as Generation Y, a demographic that is enthusiastic about online and social gaming, comes of age and enters the workforce. Southeast Asia, in particular, has been identified as a region of the world that is especially promising for the impact of gamification because of online gaming trends, responsiveness to advertisements in online games, and high rates of smartphone penetration.[168]

Gamification has been an integral part of the consumer experience for some time now; companies have incentivized their loyal customer base for decades with frequent flyer-style programs and other cumulative reward systems. Today Foursquare, a mobile app that has over 45 million users, brings gamification into the realm of social media, rewarding users with points, titles, and even tangible bonuses including coupons and discounts for checking-in to local businesses and writing reviews, which they can post on social media and share with their followers.[169] As the correlation between gamification and increased engagement grows stronger, more organizations, including schools, are seizing the potential for game mechanics to transform the daily workflow into a rewarding, fun, and memorable experience.

In the last five years, games have converged with natural user interfaces to create an experience for players that mimics real life. Gaming consoles such as Microsoft Kinect, Xbox One, and PS4 incorporate motion sensor and voice controls that offer kinesthetic experiences that have been honed for rehabilitative and educational purposes. Researchers from Microsoft Research Asia and Seoul National University developed a program for Microsoft Kinect called "Stroke Recovery," a gamified exercise platform that offers an efficient, cost effective method of therapy that can be done at home.[170] Similarly, educational companies such as Kinems are developing games to help children with disabilities. Using Microsoft Kinect motion sensor technology and cloud-based software, Kinems offers schools a game-based approach to help children improve their eye-hand coordination, short-term memory, attention span, ability to follow directions, and problem solving.[171]

Relevance for Teaching, Learning, or Creative Inquiry

Games that have gained mainstream popularity outside of school are often viewed in a new light when they are placed in an educational context. The best selling MMO game, Minecraft, is a good example; the premise is equally appealing to children and adults; there are no prescribed goals, and players are free to explore

a seemingly infinite virtual space and construct or deconstruct their surroundings with blocks of various materials.[172] With thousands of children playing in their free time, and learning math and design skills along the way, school leaders are taking increasing note of Minecraft's potential for learning. BBC Radio 5 identified at least 150 schools in the United Kingdom that already use Minecraft to reinforce collaboration. The game was highlighted as a potential gateway to computer science, as players often are required to use programming skills to overcome challenges within the virtual world.[173]

Gamified learning environments in practice can motivate learners to engage with subjects in an emotionally stimulating way. This can be seen in Le Salésien High School in Quebec, where 11th grade students are studying physics as warriors, mages, and healers in a digital role-playing game called Classcraft. Developed by a teacher and web developer at the school, Classcraft was designed to be easy-to-use, applicable to any subject. It requires only a laptop and projector to introduce gamification to the classroom. Young shared that Classcraft has effectively motivated learners to keep up with their work because of the immediate results they see when they level up and gain experience points in the game as opposed to waiting for their report card to see their progress.[174]

Digital badging is being implemented not only for the learner's benefit, but for the teacher's, too. The World's of Learning program at New Milford High School (NMHS) in New Jersey was developed to encourage the school's teachers to learn about technology tools and applications in the classroom.[175] Aligned with both ISTE's NETs Standards for Teachers and Common Core standards, the World's of Learning program was intended by its creator to be a digital method of tracking and sharing informal, on-the-job learning experiences. The badges can be presented on Credly, a free, universal badge sharing platform; Mozilla OpenBadge; on teachers' websites or blogs; and on the NMHS World's of Learning website. At the end of the year, teachers can incorporate their digital badges into their professional growth portfolios, which they present at their annual evaluation conference.[176]

Games and Gamification in Practice

The following links provide examples of games and gamification in use that have direct implications for K-12 education:

GameUp
go.nmc.org/gameup
GameUp by BrainPOP showcases 103 games from 41 different partners, and the game content spans 396 BrainPOP topics — all aligned to core curriculum. > *Practice*

Idaho Teen GameLab
go.nmc.org/itgl
Idaho Teen GameLab is a six-week, online academic camp that leverages 3D GameLab, a quest-based learning platform, to provide career and college exploration opportunities in the field of digital game design. Idaho students can build, play, and showcase their games through an interactive learning experience and attend virtual events with industry experts. > *Practice*

Minecraft at Viktor Rydberg
go.nmc.org/minecr
At the Viktor Rydberg school in Sweden, teens take a mandatory course on Minecraft, where they learn about city planning and environmental issues. > *Practice*

Quest to Learn
go.nmc.org/quest
Quest to Learn, a New York City charter school, uses core principles of game design as a framework to help students become lifelong learners and design thinkers. > *Leadership*

For Further Reading

The following resources are recommended for those who wish to learn more about games and gamification:

Here's Why We Need Video Games In Every Classroom (Video)
go.nmc.org/hereswhy
(Jordan Shapiro, *Forbes*, 19 March 2014.) A game-based learning expert explains how video games can move us toward a culture of intrinsic motivation, self-reflection, and mindful interaction with the world in a way that is globally scalable. > *Leadership*

Math, Science, History: Games Break Boundaries Between Subjects
go.nmc.org/boundaries
(Jordan Shapiro, *MindShift*, 8 May 2014.) The author explores how game-based learning creates an interdisciplinary learning environment so that the borders between subject disciplines become ambiguous. > *Practice*

Supporting Teachers in the Process of Adoption of Game Based Learning Pedagogy
go.nmc.org/supporting
(Valérie Emin-Martinez, Muriel Ney, European Conference on Games-Based Learning, 2013.) This paper proposes a model for teachers to integrate digital games and game-like activities such as role-playing and simulations into the classroom based on a study of six teachers adopting game-based learning for the first time. > *Leadership*

Learning Analytics

Time-to-Adoption Horizon: Two to Three Years

Learning analytics is an educational application of web analytics, a science that is commonly used by businesses to analyze commercial activities, identify spending trends, and predict consumer behavior. Education is embarking on a similar pursuit into data science with the aim of learner profiling, a process of gathering and analyzing large amounts of detail about individual student interactions in online learning activities. The goal is to build better pedagogies, empower students to take an active part in their learning, target at-risk student populations, and assess factors affecting completion and student success. For learners, educators, and researchers, learning analytics is already starting to provide crucial insights into student progress and interaction with online texts, courseware, and learning environments used to deliver instruction. Students are beginning to experience the benefits of learning analytics as they engage with mobile and online platforms that track data to create responsive, personalized learning experiences.

Overview

Data are routinely collected, measured, and analyzed in the consumer sector to inform companies about nearly every aspect of customer behavior and preferences. A number of researchers and companies are working to design similar analytics that can reveal patterns in learning-related data that could be used to improve learning both for individual students, and across institutions and systems. Learning analytics are used more extensively in university settings, but K-12 schools are experimenting with easy-to-use, less intensive adaptive systems such as the online course provider Khan Academy that includes adaptive assessment, data visualizations, and badges.[177] Similarly, the Australian online platform Mathspace is an adaptive math program that provides guided feedback as students work through math problems.[178] School leaders are just beginning to understand which data is useful for advancing learning, as well as the scope of privacy and ethics issues; however, the potential of using data to improve services, retention, and student success is already becoming evident.

Along with personalizing the learning experience, learning analytics can also affect the way learning is organized in a classroom. In the Finnish upper secondary school Martinlaakson Lukio, students participate in a math course autonomously. Using paper materials and formative assessment tools embedded in a learning management system, they learn at their own pace. As a result, teachers have more time to concentrate on students' individual needs. This implementation of learning analytics not only assures that students are learning the required content, but also teaches them self-evaluation skills.[179]

New kinds of visualizations and analytical reports are being developed to guide administrative and governing bodies with empirical evidence as they target areas for improvement, allocate resources, and assess the effectiveness of programs, schools, and entire school systems. As online learning environments increasingly accommodate thousands of students, researchers and companies are looking at very granular data around student interactions, building on the tools of web analytics. MyDistrict360, for example, provides a customizable portal for teachers and administrators to visualize student data and financial information, with the aim of enabling schools to more effectively provide personalized attention to students and forecast budgets.[180] As the body of knowledge around learning analytics from projects and studies continues to grow over the next few years, school and government leaders will be much more informed about performance measurement statistics and how to use them to guide learning outcomes and educational policy.

Relevance for Teaching, Learning, or Creative Inquiry

Learning analytics is beginning to gain traction in schools. Sophisticated web-tracking tools are already being used by leading institutions to capture precise student behaviors in online courses, recording not only simple variables such as time spent on a topic, but also much more nuanced information that can provide evidence of critical thinking, synthesis, and the depth of retention of concepts over time. As behavior-specific data is added to an ever-growing repository of student-related information, the analysis of educational data is increasingly complex, and many statisticians and researchers are working to develop new kinds of analytical tools to manage that complexity.

The predictive aspect of learning analytics is anticipated to transform the very nature of teaching and learning, helping to address growing concerns about overall outcomes like university and job readiness. Predictive analytics assesses student data such as attendance, subjects taken, and testing to help surface early signals that indicate if a student is struggling, allowing teachers and schools to address issues quickly. While the use of predictive analytics is more common at the university level, innovation in this area is beginning to occur at the school level as well. An evaluation specialist at Montgomery County Public Schools in Maryland, for example, devised a tracking formula that can predict, with surprising accuracy, which students will drop out of high school—as early as their second semester of first grade.[181]

K-12 schools have also started piloting online assessment tools in hybrid classes, where teachers are gaining experience using new forms of data. Hybrid classes, which blend online with traditional face-to-face class activities, present the opportunity for automated data collection and instructional customization. By combining computer-based instruction with data analysis features, teachers can track students' progress in the curriculum and determine how best to meet their individual needs. Hundreds of primary and secondary schools in the U.S. and across Europe are currently using the LMS, "Itslearning," to facilitate this digital strategy.[182] The "Itslearning" platform, for example, provides Flint High School in the UK with course dashboards that enable both teachers and students to get quick assessments of learning inside and outside of the classroom.[183] As more schools experiment with online assessment tools, leaders and policy makers will have more findings to inform the guidelines for the effective adoption of these tools.

Learning Analytics in Practice

The following links provide examples of learning analytics in use that have direct implications for K-12 education:

LACE
go.nmc.org/lace
LACE is a collaboration of European partners who seek to reduce risks and increase the benefits of learning analytics through unity of research, policy, and practice, while building communities of practice in the field.
> *Leadership*

Learning Analytics at Martinlaakson Lukio
go.nmc.org/marti
At Finnish upper secondary school Martinlaakson Lukio, students use their own learning data to self-assess in order to advance through the course. The method is based on Bloom's mastery learning model and it bypasses the need for final exams. > *Practice*

State Educational Technology Directors Learning Analytics Initiatives
go.nmc.org/set
A range of initiatives led by State Educational Technology Directors in the U.S. are focused on data standards and interoperability issues that will help schools and school systems use learning data streams to track student progress over time. > *Policy*

For Further Reading

The following articles and resources are recommended for those who wish to learn more about learning analytics:

How Can Educational Data Mining and Learning Analytics Improve and Personalize Education?
go.nmc.org/datamin
(*EdTech Review*, 18 June 2013.) Educational data mining uses emerging tools and algorithms to discover patterns that can answer questions regarding student progress and grading. Some challenges include hiring an involved IT department to help plan for collecting and maintaining data and choosing the most cost-effective learning solution. > *Leadership*

Learning Analytics Now a Key Feature of School Software
go.nmc.org/feat
(*eSchool News*, 14 March 2014.) This article describes the data analytics features of popular school software in a progression of personalizing learning for each student. The growing capabilities of data dashboards provide teachers and administrators with information on each student's progress. > *Practice*

Understanding Education through Big Data
go.nmc.org/underst
(Lyndsay Grant, *DML Central*, 25 October 2013.) The author addresses the implications of big data in education. If a child's data trail includes how they learn, where their strengths and weaknesses lie, and what kinds of teaching they might respond to, that student's identity will be seen through a lens of their data.
> *Leadership*

The Internet of Things

Time-to-Adoption Horizon: Four to Five Years

The Internet of Things is a network of connected objects that link the physical world with the world of information through the web. The advent of TCP/IP v6, launched in 2006, expanded the capabilities of the Internet, and enabled objects, sensors, and devices to be addressable and thus findable across the Internet.[184] This augmented address space is particularly useful for tracking objects that monitor sensitive equipment or materials, point-of-sale purchases, passport tracking, inventory management, identification, and similar applications. Embedded chips, sensors, or tiny processors attached to an object allow helpful information about the object, such as cost, age, temperature, color, pressure, or humidity to be transmitted over the Internet. This simple connection allows remote management, status monitoring, tracking, and alerts if the objects they are attached to are in danger of being damaged or spoiled. Many web tools allow objects to be annotated with descriptions, photographs, and connections to other objects, and other contextual information; the Internet of Things makes access to these data as easy as it is to use the web.

Overview

The Internet of Things, a concept advanced by IP co-creator Vint Cerf, is the next step in the evolution of smart objects — interconnected items in which the line between the physical object and digital information about it is blurred. The advent of IPv6 has extended the Internet address space significantly, thus providing an avenue for any object, similar to today's webcams or shared printers that use the Internet to transmit and receive data and information from an object or piece of equipment. On the consumer side, we already have Internet-enabled phones, thermostats, picture frames, and office equipment. Some pundits predict the next wave as Internet-enabled electric meters that use the Smart Grid to let your house know to raise the ambient temperature a degree to help offset a peak load.[185] Indeed, Internet pioneer Vint Cerf sees the Smart Grid as an accelerator for the Internet of Things.

While there are many examples of what the Internet of Things might look like as it unfolds, it is still today more concept than reality, although that is changing rapidly. At the same time, the underlying technologies that will make it possible, such as smart sensors that can easily be attached to everyday objects to monitor their environment or status, are all well understood, easily mass-produced, and inexpensive. These sensors are built to detect the elements and conditions around us, including sound, motion, pressure, temperature, light, and more. In many current cases, they communicate with mobile apps, alerting people, for example, if they have left the house without locking their front door through Goji Smart Lock[186] or if a storm has caused flooding in their swimming pool when they are away.[187]

It is no longer far-fetched to envision a world where all objects and devices are connected to act in concert, regardless of brand or vendor. For example, the location-awareness inherent in a smartphone knows when a user has stepped foot into a grocery store and could automatically communicate with sensors inside the user's refrigerator to let them know what food has expired and needs to be replaced. When that person returns from the grocery store, simply opening the front door would cue the Nest Learning Thermostat to adjust the temperature to their pre-stated preference.[188] In this scenario, the objects people own are entirely responsive to their needs, making life more convenient. The Nest, for instance, has proven to save owners 20% on their energy bills by allowing them to remotely raise or drop the temperature, or even turn off the system.[189]

Relevance for Teaching, Learning, or Creative Inquiry

While Internet-enabled appliances are gaining traction in the consumer industry, concrete and well-documented implementations for teaching and learning are difficult to find, particularly in the K-12 sector, though potential applications are easy to imagine. The Internet of Things is already being leveraged in informal learning settings, such as museums, where staff monitor the conditions of paintings and ancient artifacts in real-time through sensors. These devices can alert humans to long-term problems associated with changes in condition, or better yet, trigger other systems to initiate change that will ameliorate or reverse environmental conditions that are detrimental to the care and preservation of collections and individuals. At the Metropolitan Museum of Art, for example, a partnership with IBM has enabled the installation of interlinked sensors to track

the temperature and humidity, along with the artworks' response to climatic conditions.[190]

Emerging applications of this sort of technology are pushing the boundaries and depth of information that can be made accessible to the public. Archaeologists from the University of Bristol are embedding historical objects from the transatlantic slave trade for "Reflector," a project that aims to share stories through authentic pieces of history that would otherwise not be available to the masses.[191] Every artifact has a story and presents an opportunity for learning about history and culture, and the Internet of Things is making it easier — and more automatic — to communicate them.

It is no longer far-fetched to envision a world where all objects and devices are connected to act in concert.

In schools, the potential of the Internet of Things is still largely being explored through research efforts. The DISTANCE consortium, for instance, has launched a project in which eight schools across the United Kingdom help define how these technologies can enhance learning in science, technology, and geography by creating an information hub in the cloud using Xively Cloud Services, an open and massively scalable cloud platform purpose-built for the Internet of Things.[192] The goal of this program is for the consortium to ultimately develop Internet of Things resources to aid teaching and learning. Capabilities common in the consumer sector today make it easy to envision a school experience where students are recognized as soon as they step foot on campus, and everything from science laboratory equipment to lockers automatically calibrate themselves to suit their specifications and needs.

The Internet of Things in Practice

The following links provide examples of the Internet of Things in use that have direct implications for K-12 education:

Internet of Things Academy
go.nmc.org/iota
The Internet of Things Academy is part of Sony's Futurescapes project that explores the development of an open, educational Internet of Things platform to encourage creativity, collaboration, and technological literacy. > *Leadership*

Internet of Things Hackathon
go.nmc.org/nycgen
New York City Generation Tech students, along with 35 other middle and high school students, spent an intensive weekend building mobile apps with developers at the AT&T Internet of Things Hackathon. > *Practice*

UK Internet of Things Pilot
go.nmc.org/iotuk
Children in eight UK schools will be given access to new technology as part of a pilot program to define how the Internet of Things can enhance learning in science, technology, and geography. > *Practice*

For Further Reading

The following articles and resources are recommended for those who wish to learn more about the Internet of Things:

Beyond Online Classes: How The Internet of Everything Is Transforming Education
go.nmc.org/iotcisco
(Dave Evans, *The Huffington Post*, 22 August 2013.) The Chief Futurist at Cisco Systems explains how networked connections among people, processes, data, and objects will redefine what students need to learn, and why. > *Practice*

The Internet of Things Academy: Scoping Report
go.nmc.org/superflux
(*Superflux*, March 2013.) This report from the Internet of Things Academy elaborates on the potential impact of the Internet of Things, presents a roadmap, and aims to build a community around IoT innovation. > *Leadership*

What's Holding Up The Internet Of Things
go.nmc.org/hol
(Brian Proffitt, *ReadWriteWeb*, 14 June 2013.) While the Internet of Things holds promise for education, applications of it are still in the long-term horizon. The author discusses barriers to imminent advancements in the field, including a lack of consensus around a standard protocol. > *Leadership*

Wearable Technology

Time-to-Adoption Horizon: Four to Five Years

Wearable technology refers to devices that can be worn by users, taking the form of an accessory such as jewelry, sunglasses, a backpack, or even actual items of clothing such as shoes or a jacket. The benefit of wearable technology is that it can conveniently integrate tools that track sleep, movement, location, and social media. There are even new classes of devices that are seamlessly integrated with a user's everyday life and movements. Google's "Project Glass" was one of the earliest examples, and enabled a user to see information about their surroundings displayed in front of them. Smart watches are becoming commonplace, allowing users to check emails and perform other productive tasks through a tiny interface. A rapidly growing category of wearable technology takes advantage of the burgeoning interest in the "quantified self." The Jawbone UP and Fitbit bracelets are two examples that track how you eat, sleep, and move. Empowered by these insights, many individuals now rely on these technologies to improve their lifestyle and health. Today's wearables not only track where a person goes, what they do, and how much time they spend doing it, but now what their aspirations are and when those can be accomplished.

Overview

Wearable technology is not a new category; one of the most popular early incarnations of the technology was HP's calculator watch, which was introduced in the 1980s.[193] Since then, the field has advanced significantly, but the overarching theme behind the technology remains the same — convenience. Portable, lightweight, and often taking the place of an accessory that the user already has, wearable tools are meant to go anywhere. Effective wearable devices become an extension of the person wearing them, allowing them to comfortably engage in everyday activities, such as checking and responding to emails and other tasks that help teachers and students to stay productive on-the-go.

The latest turn in wearable technology is a host of devices that are linked to the quantified self — the phenomenon of people tracking data that is relevant to making improvements to their health and fitness by monitoring their activities. The previously mentioned Fitbit, for example, is a small wristband that tracks wearers' daily activities, including sleep patterns, steps taken, and calories burned.[194] Through wireless and automatic syncing between the Fitbit and smartphones, tablets, and laptops, users can see real-time progress across their devices. The Jawbone UP wristband employs similar functionalities, allowing wearers to track sleep, movement, and dietary information that is automatically populated in the accompanying mobile UP app.[195] The experience can easily turn into a social one as people share their accomplishments with other users and team up to track and achieve specific goals. It is easy to envision applications of these wearables in K-12 physical education classes to teach students about nutrition and exercise and to help them establish healthy habits early on.

Though wearable technology does not yet have many recorded applications in school classrooms, researchers and scientists are already innovating the next generation of these devices. Described as embeddable technology that is implanted underneath the skin, this category gives a whole new meaning to the term "wearable." An electronic engineer, for example, has designed a GPS-enabled shoulder implant called Southpaw that will prevent people from getting lost during outdoor expeditions. Another engineer has pioneered magnets that can be embedded into users' ears allowing them to listen to audio at any time. While implanted hardware will not likely be seen in classrooms anytime soon, advances in wearable technology are gradually eliminating the need for cumbersome devices and the sheer number of tools people own in the pursuit of leading more productive lives.[196]

Relevance for Teaching, Learning, or Creative Inquiry

Currently, the number of new wearable devices in the consumer sector seems to be increasing daily, greatly outpacing the implementation of this technology in schools. The education sector is just beginning to experiment with, develop, and implement wearable technologies, though the potential applications are significant and vast. Smart jewelry, clip-on pins, or other accessories, for example, could alert science students working in laboratories to hazardous conditions. So far these types of devices are mostly being developed in university labs, including "ExposureTrack" — a wearable

designed at Arizona State University in collaboration with inXsol that alerts people of working conditions that could potentially endanger their health.[197]

One of the most compelling uses of wearable technology in K-12 is their potential to enhance fieldtrips and fieldwork. For instance, wearable cameras such as the Kickstarter-funded, GPS-enabled Memoto can instantly capture hundreds of photographs or data about a user's surroundings on a class trip to a museum or an offsite geology dig that can be later accessed via email or other online application.[198] The Contour Video Camera is another such device, currently favored by extreme athletes, that records and streams HD video.[199] There is an increasing demand from users for all of their special moments to be seamlessly captured, but it is becoming less desirable to have to carry cumbersome devices. As technologies are continuously designed to be smaller and more mobile, wearable devices are a natural progression in the evolution of technology.

In 2013, augmented reality (AR)-enabled glasses for education received a lot of attention, due to the release of Google Glass. These glasses display relevant information for users as they go about their daily routines, allowing them to access the Internet via voice command, communicate email replies, and more. While the future of Glass is uncertain at this writing, there are potential applications for this type of technology in learning settings. A Michigan science teacher used Glass to make a series of bite-size videos showing the math and science of everyday life from a first-person perspective.[200] A crop of other AR glasses has emerged, via brands such as Meta, Epson, and Vuzix. In May 2014, Epson began retailing their version, Moverio BT-200, for $700 — less than half the price of Glass.[201] Moverio BT-200 glasses could be considered better suited for classroom settings as they project a screen in front of the wearer's eyes that is equivalent to an 80-inch television, which could make it easier for students to engage with rich media.

Wearable Technology in Practice

The following links provide examples of wearable technology in use that have direct implications for K-12 education:

Body Heat-Powered Wearables
go.nmc.org/thermo
Researchers at the Korean Advanced Institute of Science and Technology developed an ultra-thin, flexible and bendable technology that is powered by thermoelectric energy so that a wearer's body heat will be able to keep their device powered. This could be useful for field trips and outdoor data collection for science classes. > *Practice*

Junior Varsity InvenTeam Initiative
go.nmc.org/shoe
The Junior Varsity InvenTeam Initiative is a program that cultivates creative skills in ninth and tenth grade students using invention-based design activities such as designing wearable electronics. > *Practice*

Project 2x1
go.nmc.org/twoxone
Project 2x1 is a documentary filmed with Google Glass that explores cultures of the Hasidic and West Indian communities of Crown Heights from multiple community members' perspectives in ways that traditional film crews could not capture. > *Practice*

For Further Reading

The following articles and resources are recommended for those who wish to learn more about wearable technology:

7 Rules for Designing Wearable Devices
go.nmc.org/embed
(Kevin Kitagawa, *Embedded Computing Design*, 22 April 2014.) This guide addresses the current issues facing the wearable technology market for designing the next generation of wearables. > *Leadership*

Smartwatches Can Potentially be Very Useful in Education
go.nmc.org/smartwatch
(Andreas Ødegård, *Pocketables*, 5 April 2013.) Smart watches are mostly information display devices, but the smart watch form factor has significant advantages being a small, personal information device attached directly to the wrist. It could enable quick research and interactions, such as a student sending questions to the teacher during class. > *Practice*

What Does Wearable Computing Mean for Education?
go.nmc.org/wearab
(Ben Stern, *Edu Musings*, 7 January 2014.) A K-12 technology integrationist explains how wearable computing offers authentic real-world contexts that can be leveraged for mobile app development among young learners. > *Practice*

The 2014 NMC Horizon Project K-12 Expert Panel

Larry Johnson
Co-Principal Investigator
New Media Consortium
United States

Keith Krueger
Co-Principal Investigator
CoSN
United States

Samantha Adams Becker
Horizon Project Director
New Media Consortium
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Troy Bagwell
Decatur Independent School District
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Fiona Banjer
Department of Education, Training & Employment, Queensland
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Russell Beauregard
Intel
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Roger Blamire
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Deirdre Butler
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Gavin Dykes
Cellcove Ltd.
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Oklahoma State Department of Education
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Michael Flood
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Claus Gregersen
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Lisa Gustinelli
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Batavia Public Schools
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Flat Connections
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Holly Ludgate
New Media Consortium
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Vicki Lyons
School District of La Crosse
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Rob Mancabelli
BrightBytes
United States

Marcia Mardis
Florida State University
United States

Cristiana Mattos Assumpçao
Colégio Bandeirantes
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