

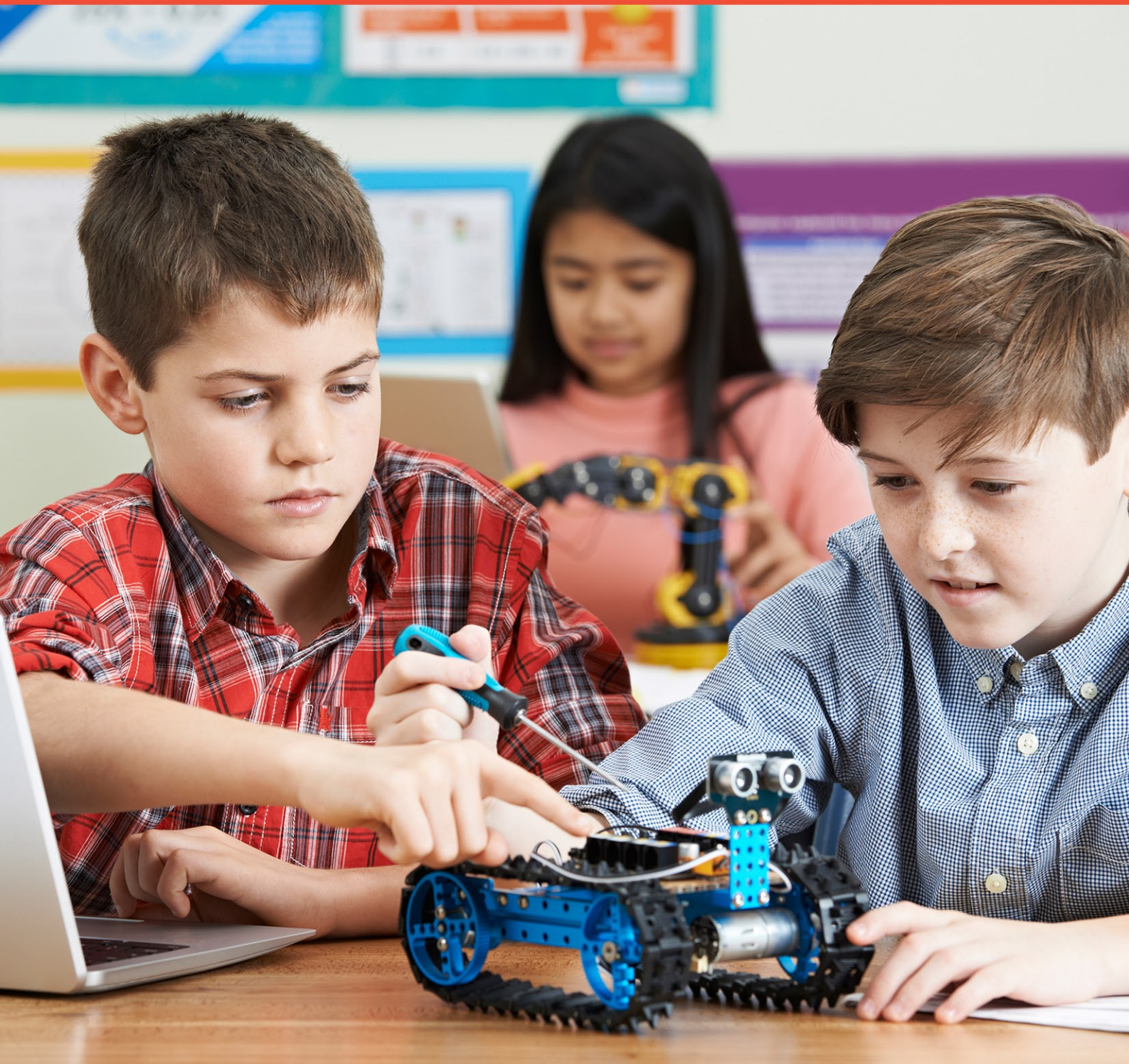


Horizon Project

# 2017 NMC Technology Outlook

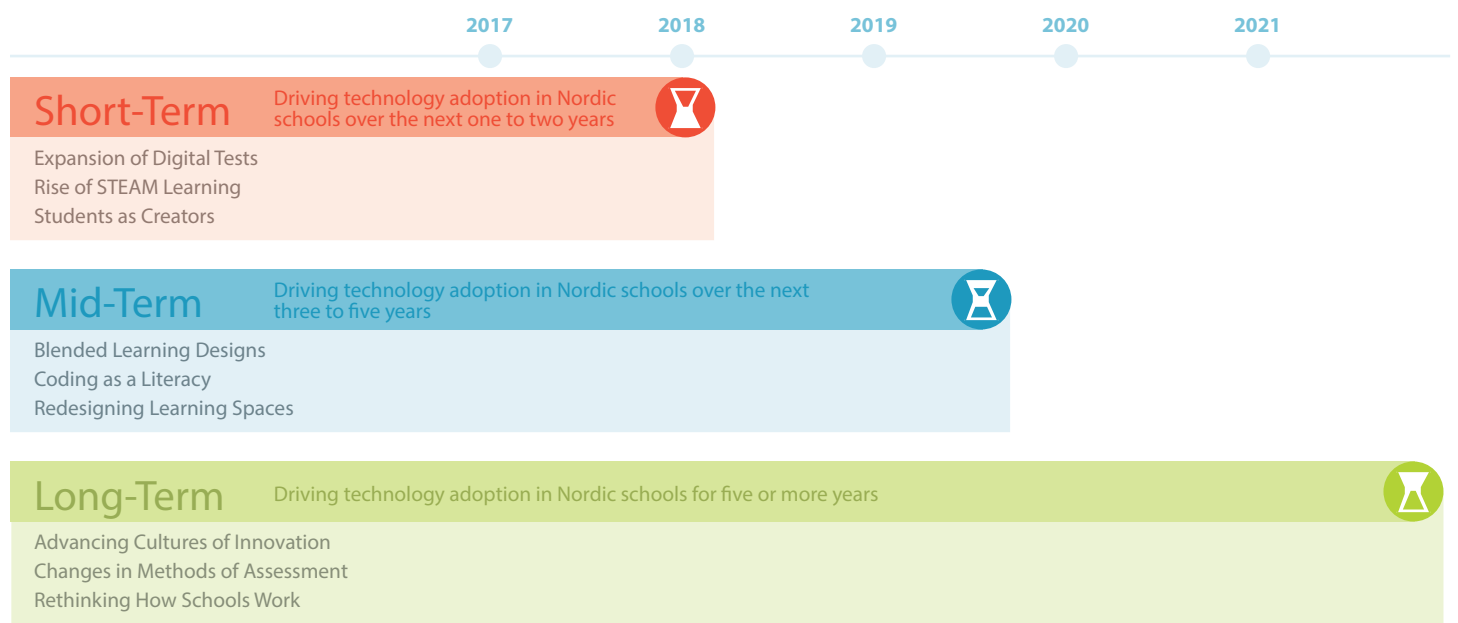
Nordic Schools

A Horizon Project Regional Report

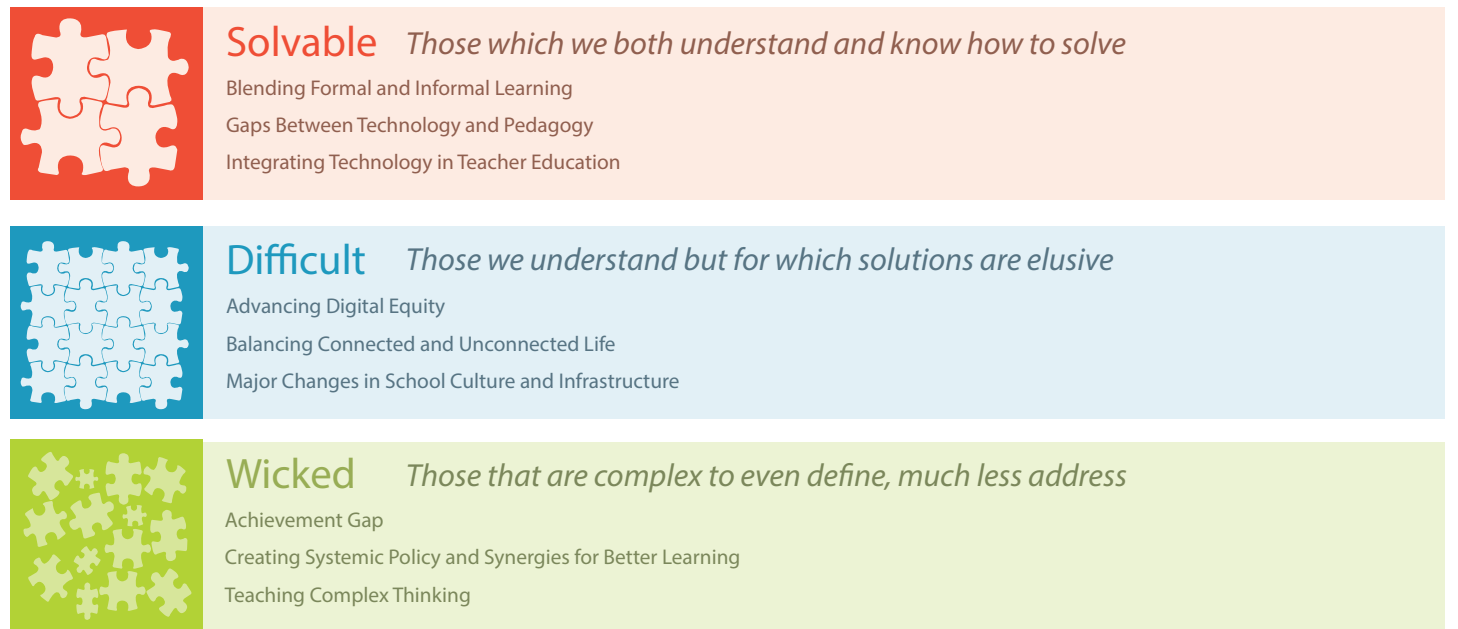


# 2017 NMC Technology Outlook > Nordic Schools at a Glance

## Key Trends Accelerating Technology Adoption in Nordic Schools



## Significant Challenges Impeding Technology Adoption in Nordic Schools



## Important Developments in Educational Technology for Nordic Schools



# 2017 NMC Technology Outlook for Nordic Schools

## *A Horizon Project Regional Report*

<b>Executive Summary</b> .....	1
<b>Introduction</b> .....	2
<b>Key Trends Accelerating Technology Adoption</b> .....	5
<b>Significant Challenges Impeding Technology Adoption</b> .....	7
<b>Time-to-Adoption Horizon: One Year or Less</b>	
▪ 3D Printing.....	9
▪ Games and Gamification .....	10
▪ Makerspaces .....	11
▪ Mobile Learning.....	12
<b>Time-to-Adoption Horizon: Two to Three Years</b>	
▪ Adaptive Learning Technologies.....	13
▪ Artificial Intelligence/Machine Learning .....	14
▪ Mixed Reality .....	15
▪ Robotics.....	16
<b>Time-to-Adoption Horizon: Four to Five Years</b>	
▪ Speech-to-Speech Translation.....	17
▪ Virtual and Remote Laboratories .....	18
▪ Virtual Assistants .....	19
▪ Wearable Technology .....	20
<b>Methodology</b> .....	21
<b>2017 Horizon Project Nordic Expert Panel</b> .....	23
<b>End Notes</b> .....	24



**THE NORWEGIAN  
CENTRE FOR  
ICT IN EDUCATION**

*2017 NMC Technology Outlook for Nordic Schools  
A Horizon Project Regional Report*

is a collaboration between

**The New Media Consortium**

and

**The Norwegian Centre for ICT in Education**

© 2017, The New Media Consortium.

**Creative Commons License**

Permission is granted under a Creative Commons Attribution 4.0 License to replicate, copy, distribute, transmit, or adapt this report freely provided that attribution is provided as illustrated in the citation below. To view a copy of this license, visit <http://creativecommons.org/licenses/by/4.0/>.

**Citation**

Adams Becker, S., Cummins, M., Freeman, A., and Rose, K. (2017). [2017 NMC Technology Outlook for Nordic Schools: A Horizon Project Regional Report](#). Austin, Texas: The New Media Consortium.

Cover image courtesy of BigStock Photography

978-0-9977215-9-1

## Executive Summary

The *2017 NMC Technology Outlook for Nordic Schools: A Horizon Project Regional Report* reflects a collaborative research effort between the New Media Consortium (NMC) and the Norwegian Centre for ICT in Education to inform Nordic school leaders and decision-makers about significant developments in technologies supporting teaching, learning, and creative inquiry in primary and secondary education across Denmark, Finland, Norway, and Sweden.

All of the research underpinning the report makes use of the NMC's Delphi-based process for bringing groups of experts to a consensus viewpoint, in this case around the impact of emerging technologies on teaching, learning, or creative inquiry in Nordic schools over the next five years. The same process underlies the well-known *NMC Horizon Report* series, which is the most visible product of an on-going research effort begun more than 15 years ago to systematically identify and describe emerging technologies likely to have a large impact on education around the globe.

The *2017 NMC Technology Outlook for Nordic Schools* was produced to explore emerging developments in technology and forecast their potential impact expressly in a Nordic school context. In the effort that took place from October through December 2016, a carefully selected panel of experts was asked to consider a host of relevant articles, news, blog posts, research, and project examples as part of the preparation that ultimately pinpointed the most notable technology topics, trends, and challenges for Nordic schools over the next five years.

Known as the 2017 Horizon Project Nordic Expert Panel, that group of thought leaders consists of knowledgeable individuals, all highly regarded in their fields. Collectively, the panel represents a range of diverse perspectives across the primary and secondary education sector. The project has been conducted under an open data philosophy, and all the interim projects, secondary research, discussions, and ranking instrumentation can be viewed at [nordic.wiki.nmc.org](http://nordic.wiki.nmc.org). The precise research methodology employed in producing the report is detailed in a special section found at the end of this report.

Nine key trends, nine significant challenges, and twelve important developments in technology were identified by the expert panel. The trends and challenges are intended to frame technology adoption in terms of the positive paradigm shifts advancing it and the obstacles impeding it. These influential discussions acknowledge that technology by itself is not a sufficient solution but instead an enabler of more effective teaching and learning approaches. Technology use must be grounded in progressive pedagogies and models that foster greater student engagement and performance. Both the trends and the challenges are placed into horizons; the trends range from long- to short-term while the challenges are classified by scope of difficulty.

Following the discussion of the trends and challenges, each of the twelve developments in technology are profiled on a single page that describes the topic and categorises it as very important for Nordic schools over the next year, two to three years, or four to five years. Every page opens with a carefully crafted definition of the highlighted development, outlines its educational relevance, points to several real-life examples of its current use, and ends with a short list of additional readings for those who wish to learn more.

Taken together, the three key sections of this report constitute a reference and straightforward technology-planning guide for educators, school leaders, administrators, policymakers, and technologists. It is our hope that this research will inform the choices that schools are making about technology to improve, support, or extend teaching, learning, and creative inquiry in Nordic countries. Education stakeholders worldwide look to the NMC Horizon Project and both its global and regional reports as key strategic technology planning references, and it is for that purpose that the *2017 NMC Technology Outlook for Nordic Schools* is presented.

## Introduction

What is on the five-year horizon for schools in Denmark, Finland, Norway, and Sweden? Which trends and technology developments will drive real transformation in primary and secondary education? What are the critical challenges for which solutions are needed? These questions regarding technology adoption and educational change steered the discussions of a body of 53 experts to produce the *2017 NMC Technology Outlook for Nordic Schools*.

Nine key trends, nine significant challenges, and twelve developments in educational technology profiled in this report are poised to impact Nordic schools. The topics converge in ways that tell a larger story about the state of teaching and learning in the region. These top five highlights capture the big picture themes of educational change that underpin the 30 topics:

**1. Advancing progressive learning approaches requires cultural transformation.** Nordic schools must be structured to promote the exchange of fresh ideas and identify successful models within and outside of schools — with student success at the centre. Embracing evidence-based approaches to technology deployment, aligned with pedagogy, can impart greater digital fluency.

**2. Real-world skills are needed to deepen learning outcomes, better preparing students for university and the workforce.** The advent of makerspaces, classroom configurations that enable active learning, and the inclusion of coding and robotics are providing students with ample opportunities to create, iterate, and experiment in ways that spur complex thinking.

**3. Lifelong learning is the lifeblood of education.** Progressive teaching approaches that creatively incorporate technology can foster long-term learning habits for students. Teachers require the same level of care; ongoing training and the integration of digital contexts in initial teacher education programmes is critical for closing chasms between technology and pedagogy.

**4. Online, mobile, and blended learning are foregone conclusions.** If Nordic schools do not already have robust strategies for integrating these now pervasive approaches, then they will not remain relevant. An important step is tracking how these models are enriching learning outcomes.

**5. More engaging learning experiences and personalisation are on the rise.** The goal of technologies like 3D printing, games and gamification, and mixed reality is to provide stimulating activities that immerse students in a variety of creative learning contexts. Concurrently, adaptive learning platforms, powered by the latest artificial intelligence technologies, can deliver content tailored to each student's specific needs, better illuminating strengths and areas for improvement.

The work of the 2017 Horizon Project Nordic Expert Panel acknowledges that technology adoption in schools across the region can be both accelerated by the recognition of and hampered by the complexities of these themes. A comparison between the 2017 panel and the 2015 Scandinavian Panel illuminates progress or stalling in some areas. Additionally, it is important to look beyond the unique context of Nordic primary and secondary education to view how technology-driven trends and challenges are impacting the rest of the world. As such, the top three most highly ranked trends and challenges from three reports are included in the related tables in this summary, and are organised by categories described in the next sections of this report.

The tables illustrate the choices of the Nordic experts compared with those who contributed to the *NMC/CoSN Horizon Report > 2016 K-12 Edition*, which looked at technology uptake from a global perspective, and the *2015 NMC Technology Outlook for Scandinavian Schools* with perspectives on technology impact in Denmark, Norway, and Sweden — an appropriate benchmark for progress in the Nordic region. Altogether, the three reports encompass a group of 159 acknowledged experts.

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

2015 Technology Outlook for Scandinavian Schools	2017 Technology Outlook for Nordic Schools	NMC/CoSN Horizon Report 2016 K-12 Edition
<b>Long-Term Trend</b>		
Growth of New Professions Entering Schools	Rethinking How Schools Work	Redesigning Learning Spaces
<b>Mid-Term Trend</b>		
Data-Driven Learning and Assessment	Coding as a Literacy	Collaborative Learning
<b>Short-Term Trend</b>		
Expansion of Digital Tests	Students as Creators	Coding as a Literacy

As shown in Table 1, the top priorities of the Nordic panel have evolved from those of the 2015 Scandinavian panel. Nordic experts viewed rethinking how schools work as the most significant long-term trend, reflecting a gradual movement towards reinventing traditional classroom paradigms to embrace more active learning and the cultivation of real-world skills. This is evident in the Norwegian Ministry of Education and Research's Knowledge Promotion Reform, a proposal to refresh current subjects taught in school to foster more opportunities for in-depth learning.<sup>1</sup>

Additionally, students as creators was identified as a top trend, a concept embraced by the other panels but prioritised higher by the Nordic panel. Its short-term horizon placement indicates that new developments in this area are taking hold — often documented informally. For example, an 8<sup>th</sup> grade biology teacher in Sweden discusses his decision to end testing and instead have students demonstrate complex concepts by creating 3D visualisations to teach the material to 4<sup>th</sup> and 5<sup>th</sup> year students.<sup>2</sup>

While the global expert panel perceived coding as a short-term trend — one that has only recently emerged — programming has been a part of government agendas and school curricula in Nordic countries in recent years. In 2016, coding became a core part of the Finnish curriculum, beginning in year one of primary school.<sup>3,4</sup>

The 2017 Nordic experts also agree that technology adoption is often hindered by both local and systemic challenges that make it difficult to discover and implement new tools and approaches.

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

2015 Technology Outlook for Scandinavian Schools	2017 Technology Outlook for Nordic Schools	NMC/CoSN Horizon Report 2016 K-12 Edition
<b>Solvable Challenge</b>		
Integrating Technology in Teacher Education	Integrating Technology in Teacher Education	Authentic Learning
<b>Difficult Challenge</b>		
Implementing Knowledge from Other Parts of Society	Advancing Digital Equity	Scaling Teaching Innovations
<b>Wicked Challenge</b>		
Systemic Policy and Synergies for Better Learning	Systemic Policy and Synergies for Better Learning	Achievement Gap

As noted in Table 2, above, both the Nordic and Scandinavian panels agreed that increasing the digital fluency of teachers is daunting, but remains a solvable challenge as initial teacher education programmes address ICT integration, along with ongoing professional development. The Danish Ministry of Education serves as an exemplar in solving this challenge as part of its initiative to advance ICT at primary and secondary schools through better access to technology for teaching and establishing clear goals for the use of digital learning resources.<sup>5</sup>

The 2017 Nordic panel emphasises the need to narrow the digital divide, acknowledging that although technology and high-speed broadband is more pervasive, not all teachers and students have equal access. As Bring Your Own Device strategies have spread throughout the region, not every household is equipped with sufficient internet access or can afford the latest gadgets. Systemic policy and synergies for better learning was originally proposed as a new topic by the 2015 Scandinavian panel, and its complexities make it a persistent challenge that has been elusive to articulate, let alone solve. There is a disconnect between digital competence policies and implementation, ultimately causing a lack of technology savvy among teachers and students.

Fuelled by the key trends and impeded by significant challenges selected by the panel, the 12 important developments in technology presented in the body of this report reflect our experts' opinions as to which of the nearly 50 technologies considered will be most important to Nordic schools over the five years following the publication of the report.

**Table 3: Comparison of “Final 12” Topics Across Three NMC Horizon Research Projects**

2015 Technology Outlook for Scandinavian Schools	2017 Technology Outlook for Nordic Schools	NMC Horizon Report 2016 K-12 Edition
<b>Time-to-Adoption Horizon: One Year or Less</b>		
Bring Your Own Device Cloud Computing Flipped Classroom Games and Gamification	3D Printing Games and Gamification Makerspaces Mobile Learning	Bring Your Own Device Cloud Computing Makerspaces Online Learning
<b>Time-to-Adoption Horizon: Two to Three Years</b>		
Learning Analytics Makerspaces Open Content Social Networks	Adaptive Learning Technologies Artificial Intelligence Mixed Reality Robotics	3D Printing Adaptive Learning Technologies Robotics Virtual Reality
<b>Time-to-Adoption Horizon: Four to Five Years</b>		
The Internet of Things Robotics and Programming Speech-to-Speech Translation Wearable Technology	Speech-to-Speech Translation Virtual and Remote Laboratories Virtual Assistants Wearable Technology	Artificial Intelligence Next-Generation Batteries Volumetric/Holographic Displays Wearable Technology

As reflected in the collective choices above, Nordic schools are ahead of the global curve in the exploration and integration of many emerging technologies. Nordic experts viewed 3D printing as imminently poised for mainstream adoption with artificial intelligence only a maximum of three years away. In no circumstances were the Nordic developments positioned on farther horizons than that of the Scandinavian or global panels.

Unique to the Nordic panel's selection was mixed reality — the blending of augmented reality with the physical realm — as well as virtual assistants, which have elevated in sophistication thanks to greater artificial intelligence and far-field microphones that no longer rely on users speaking directly into their smartphones.

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



## Key Trends Accelerating Technology Adoption

The developments in technology featured in the NMC Horizon Project are embedded within a contemporary context that reflects the realities of the time, both in the sphere of education and in the world at large. To assure this perspective, each panel member has researched, identified, and ranked key trends that are currently affecting teaching, learning, and creative inquiry in Nordic schools, and used these as a lens for the work of predicting the uptake of emerging technologies. These nine trends, which the panel agreed are very likely to drive technology planning and decision-making over the next five years, are sorted into three time-related categories: short-term trends that will last for the next one to two years and are bound to become pervasive in schools, and two categories of slower trends that are growing more incrementally in Nordic schools.

### Short-Term Trends

#### *Driving technology adoption in Nordic schools over the next one to two years*

**Expansion of Digital Tests.** As teachers and schools are increasingly making learning activities available online, it is a natural next step for more formal assessments to be digitised. In Denmark and Norway, national summative exams are now taking place online and the government has plans to expand these efforts to other types of tests. The Norwegian Directorate for Education and Training provides the virtual testing environment in Norway, but the use of learning management systems for other types of assessment varies. The Future Tests and Test Environments conference in Sweden stressed that this global trend towards digital test environments makes test administration, scoring, and reporting more effective and secure.<sup>6</sup>

**Rise of STEAM Learning.** In recent years, there has been a growing emphasis on developing stronger science, technology, engineering, and mathematics (STEM) curriculum and programmes, as these disciplines are widely viewed as the means to boost innovation and bolster national economies. As a response to the focus on STEM learning at schools, some education leaders believe there is the need for a more balanced curriculum that integrates disciplines such as the arts, design, and humanities into the sciences. This notion has fostered the STEAM learning movement, in which the A stands for “art+.” An Icelandic thought leader, for example, is piloting a STEAM learning workshop using Bjork’s artwork “Biophilia” to teach multimodal literacies.<sup>7</sup>

**Students as Creators.** A shift is taking place in schools as learners are exploring subject matter through the act of creation rather than the consumption of content. A vast array of digital tools is available to support this transformation in primary and secondary education, giving rise to an increasing level of comfort with producing media. Many educators believe that honing these kinds of creative skills in learners can lead to deeply engaging learning experiences in which students become the authorities on subjects through investigation, storytelling, and production. The recent addition of a makerspace at Hultsfred gymnasium in Sweden fosters opportunities for students in math, science, and language to engage in more creative and hands-on activities in school.<sup>8</sup> In the School of the Future project, 85 Danish elementary school students piloted a digitally-enriched environment where all regular lessons were replaced with workshops and cross-disciplinary project work, involving programming, fabrication technologies and media production.<sup>9</sup>

### Mid-Term Trends

#### *Driving technology adoption in Nordic schools over the next three to five years*

**Blended Learning Designs.** Drawing from best practices in online and face-to-face methods, blended learning is on the rise at Nordic schools. Flexibility, ease of access, and the integration of sophisticated multimedia and technologies are high among the list of appeals. At Copenhagen’s Ørestad Gymnasium, for example, students work together with computers and tablets in large groups for most of the day, with teacher-guided instruction for the remainder.<sup>10</sup> Many lower

secondary schools in Denmark have developed 1:1 programmes, where every student has access to his or her own internet-connected device; as a result, these students performed better on an international comparative study of computer and information literacy.<sup>11</sup>

**Coding as a Literacy.** Coding refers to a set of rules that computers understand and can take the form of numerous languages, such as HTML, JavaScript, and PHP. Many educators perceive coding to stimulate computational thinking: the skills required to learn coding combine deep computer science knowledge with creativity and problem-solving. Code.org recently projected that by 2020, there will be 1.4 million computing jobs but only 400,000 computer science students to fill them. To better prepare learners from a young age, an increasing number of school leaders and technologists are making the case for embedding coding into primary and secondary education curricula. To this end, Finland is making coding a part of the country's core curriculum.<sup>12</sup>

**Redesigning Learning Spaces.** As conventional teaching models evolve and emerging technologies gain a solid foothold in Nordic classrooms, formal learning environments require an upgrade to reflect the 21st century practices taking place in them. Today, student-centric pedagogies are being embraced to better equip learners with real-world skills, and new approaches to classroom design are supporting this shift. Additionally, innovative thinking in architecture is influencing the sustainable design and construction of new school infrastructures that have the potential to significantly impact classroom practices and student learning, such as the Powerhouse Drøbak Montessori lower secondary school in Norway which is designed to strengthen students' understanding of the relationship between man and nature.<sup>13</sup>

## Long-Term Trends

### *Driving technology adoption in Nordic schools for five or more years*

**Advancing Cultures of Innovation.** Nordic thought leaders have long believed that schools can play a major role in the growth of their national economies. To breed innovation and adapt to economic needs, schools must be structured in ways that allow for flexibility and spur creativity. This notion is exemplified in Sweden, where despite having lower PISA scores than their Nordic neighbouring countries, entrepreneurship is well integrated into upper secondary school.<sup>14</sup> The importance of this activity is acknowledged by the World Economic Forum, which publishes a global competitiveness index every year that considers creativity and innovation as contributing factors; Sweden is ranked the sixth most competitive country for this reason.<sup>15</sup>

**Changes in Methods of Assessment.** The emphasis of assessment is in the midst of transitioning from evaluating what has been learned to evaluating the process of learning as a whole. Nordic schools are now focused on continuous assessment based on dialogue, rather than summative tests and exams, complemented by self- and peer assessments. The ultimate objective is to nurture self-regulated learners who can set their own learning goals and work towards them independently.<sup>16</sup> The Norwegian government's "Schools of Tomorrow" report proposes more freedom for students to delve deeper into content areas, rather than relying on tests that superficially cover too wide of a range of subjects.<sup>17</sup> New tools are also being developed to support and document online dialogue and self-assessment such as the Write to Learn method in Sweden, which provides students real-time formative feedback on their writing.<sup>18</sup>

**Rethinking How Schools Work.** 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. Changing school culture is one of Finland's four curriculum reform areas, calling for a renewal of pedagogies, learning environments, and assessment.<sup>19</sup> The multidisciplinary nature of contemporary approaches such as project-based and immersive learning has popularised creative applications of technology and fostered innovative school models that link subject matter to the real world.

## Significant Challenges Impeding Technology Adoption

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

### Solvable Challenges

*Those which we both understand and know how to solve*

**Blending Formal and Informal Learning.** As the internet has brought the ability to learn something about almost anything at the palm of one's hand, there is an increasing interest in self-directed and curiosity-based learning. These, along with life experience and other more serendipitous forms of learning, fall under the banner of informal learning, encouraging students to follow their own learning pathways. However, formally acknowledging and rewarding skills mastered outside of the classroom is compounding this challenge.<sup>20</sup> Progress is being made with the availability of the Innofactor Skilli tool, which enables Finnish and Swedish students to analyse what they have learned, as well as the quality of the learning experience, based on set targets.<sup>21</sup>

**Gaps Between Technology and Pedagogy.** Given the frequency at which new technologies develop, it is difficult to fully prepare for future innovations while understanding how they can best enhance teaching practices. As a result, school leaders make unilateral decisions to purchase devices that are not versatile and flexible enough to advance student-centred learning. They need to create a more holistic vision for how digital tools will concretely benefit students, and educators need ongoing professional development in new pedagogies and ICT-based methodologies. Fortunately, Erasmus+ provides Nordic countries with funding for these kinds of opportunities.<sup>22</sup> In Denmark, 19 schools have joined together through the digital effort eSkoler Middle to equip teachers with more digital competencies and close the gap between technology and pedagogy.<sup>23</sup>

**Integrating Technology in Teacher Education.** Despite the widespread agreement on the importance of digital competence, training in digitally-supported teaching methods is still too uncommon. Teachers require extensive exposure to ICT to be able to evaluate and choose the most appropriate tools and resources. This challenge is exacerbated by the notion that digital literacy is less about tools and more about thinking, and thus tool-specific skills have proven to be somewhat ephemeral. Researchers in Norway are beginning to identify key focus areas for initial education programmes, including multimodal modelling and authentic learning approaches.<sup>24</sup>

### Difficult Challenges

*Those we understand but for which solutions are elusive*

**Advancing Digital Equity.** Digital equity refers to uneven access to high-speed broadband, a rampant social justice issue that is not just impacting developing nations. While more schools are benefiting from improved internet connectivity, the growing pervasiveness of blended learning approaches is illuminating new gaps between those with and without ubiquitous connectivity; students are increasingly expected to engage in learning activities outside of the classroom. For students from economically disadvantaged households, the availability of broadband and sufficient computing devices is not a given.<sup>25</sup> Solving this challenge will take concerted efforts between policymakers and school leaders.

**Balancing Connected and Unconnected Life.** With technology now at the centre of many daily activities, schools must help learners understand how to balance their usage with other developmental needs. To prevent students from getting lost in the abundant sea of information and new media, Nordic schools should encourage mindful use of digital tools while making them aware of their digital footprint and the accompanying implications. As education aligns more closely with technological trends, educators should promote this balance, facilitating opportunities where students feel, digest, reflect, touch, and pursue sensorial experiences that are crucial to developing character and integrity. Later this year, Styrelsen for IT Learning is launching several campaigns and teaching programmes promoting safe navigation in the digital society.<sup>26</sup>

**Major Changes in School Culture and Infrastructure.** Adapting new pedagogies and technologies requires organisational change as a collective effort, involving school leaders and educators co-working in ways that enable open knowledge exchange. If schools expect students to be adept at collaborative learning activities, teachers and administrators must exemplify this same behaviour. Educators have varying technological expertise and can benefit from teaching each other practical and progressive models for application in the classroom. This approach can lead to the scaling of effective teaching practices but requires school environments to better support peer-to-peer training and foster opportunities for it to happen more frequently.

## Wicked Challenges

*Those that are complex to even define, much less address*

**Achievement Gap.** The achievement gap refers to an observed disparity in academic performance between student groups, especially as defined by socioeconomic status, race, ethnicity, or gender. While schools play a vital role in helping to close the gap, the challenge is rooted in underlying socioeconomic factors, making national policy initiatives paramount. Finland's Ministry of Education and Culture is establishing a comprehensive school forum by inviting all political parties in the parliament to participate in working groups, recognising that efforts to improve equality require the support of the entire nation, not just education authorities, schools, and teachers.<sup>27</sup> A recent OECD report also promotes the use of data information systems at schools to identify struggling students, along with factors that cause learning disruptions, and then connect students with better counselling, mentoring, and support.<sup>28</sup>

**Systemic Policy and Synergies for Better Learning.** Educational technologies are not yet fully exploited in the Nordic region to impart real-world skills that reflect the needs of the workforce. Triggering large-scale, sustainable changes necessitates collaborative, focused actions that engage policymakers, local communities, school leaders, educators, and learners. The Norwegian government is planning a revision of the Norwegian curriculum. They aim to clarify the different aspects of the digital skills and connect them more closely to the different subjects.<sup>29</sup> The Finnish National Board of Education also recently revised its National Core Curricula to emphasise collaboration, student autonomy, and the development of transversal competences that span subject areas. Finland's curriculum reform aims to provide educators and students more flexibility to experiment with technology-enhanced, cross-disciplinary pedagogies.<sup>30</sup> In Denmark, the University of Copenhagen led a three-year project working with six secondary schools to organise and implement teaching methods that fostered greater digital competence in students.<sup>31</sup>

**Teaching Complex Thinking.** It is essential for learners both to understand the networked world in which they are growing up and to deploy heuristic reasoning to solve the pressing problems around them. In a recent report on ICT in schools to the Swedish government, Sweden's Digitalisation Commission has proposed revisions to national curriculum and exams to integrate the use of digital tools for logical thinking, source critique, and creative problem-solving into an array of subjects.<sup>32</sup> Researchers at Aarhus University in Denmark published a paper that presents a scalable approach to implementing computational thinking in high schools.<sup>33</sup>

**Time-to-Adoption: One Year or Less****3D Printing**

Known in industrial circles as rapid prototyping, 3D printing refers to technologies that construct physical objects from three-dimensional (3D) digital content such as 3D modelling software, computer-aided design (CAD) tools, computer-aided tomography (CAT), and X-ray crystallography.<sup>34</sup> A 3D printer builds a tangible model or prototype from the electronic file, one layer at a time, through an extrusion-like process using plastics and other flexible materials, or an inkjet-like process to spray a bonding agent onto a very thin layer of fixable powder. The deposits created by the machine can be applied very accurately to build an object from the bottom up, layer by layer, with resolutions that, even in the least expensive machines, are more than sufficient to express a large amount of detail. Using different materials and bonding agents, colour can be applied, and parts can be rendered in plastic, resin, metal, tissue, and even food. This technology is used in many industries to build prototypes and models of almost any object (scaled to fit the printer) that can be conveyed in three dimensions, and sometimes at a lower cost than traditional means of modelling. Norway's Agency for Planning and Building Services recently updated their model of Oslo with a 3D printed version, a solution they found cost-effective and easy to manoeuvre when segmenting sections of the city for planning purposes.<sup>35</sup> The latest advances in 3D printing centre on expanding beyond prototyping to use in production-level outputs.<sup>36</sup>

**Relevance for Teaching, Learning, or Creative Inquiry**

- 3D printing allows for authentic exploration of objects that may not be readily available to schools, including animal anatomies, ancient artefacts, and toxic materials.
- 3D printing shows promise as a rapid prototyping and production tool, providing students with the ability to touch, hold, and even take home a concrete model of their idea.
- The exploration of 3D printing, from design to production, as well as demonstrations and participatory access, opens up new possibilities for learning activities.

**3D Printing in Practice**

- At Farimagsgade School in Denmark, an educator integrates creativity into 3D printing assignments to make geometry lessons more engaging: [go.nmc.org/baltic](http://go.nmc.org/baltic).
- The mayor of Pyhtaa, Finland launched an initiative to equip Finnish schools with 3D printers with the goal of bringing new dimensions to various school subjects including geometry, chemistry, and archaeology: [go.nmc.org/pyhtaa](http://go.nmc.org/pyhtaa).
- Rothaugen students brought Norwegian history and architecture lessons to life using 3D printers to construct models of local area 19<sup>th</sup> century buildings: [go.nmc.org/roth](http://go.nmc.org/roth).
- Students at Lyngsdalen Oppvekstsenter in Norway learned to build their own cups through a joint project with a 3D software and printing startup: [go.nmc.org/lyngen](http://go.nmc.org/lyngen).

**For Further Reading**

*7 Fun and Easy Lesson Plans to Jumpstart 3D Printing in Your Classroom*

[go.nmc.org/7fun](http://go.nmc.org/7fun)

(Jessica Adams, Makerbot, 3 June 2016.) Makerbot, the company that has increased the affordability of 3D printers, offers concrete tips and exemplars for any teachers looking to implement 3D printing into their STEAM lesson plans.

*Exploration of 3D Printers and NAO Robot in Elementary Schools*

[go.nmc.org/3dnao](http://go.nmc.org/3dnao)

(Gunver Majgaard et al., MONA, April 2014.) This article details findings from the Fremtek Project which examined the use of 3D printers and the NAO robot, an autonomous, programmable humanoid robot, in 20 Danish elementary schools.

## Time-to-Adoption: One Year or Less

### Games and Gamification

The culture around digital games is growing to encompass a substantial proportion of the world's population, and Nordic countries have a strong foothold in this industry.<sup>37</sup> 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. This potential for social interaction, combined with challenges, opportunities to succeed, potential for risk, and a sense of progress — all fundamental to many games — is psychologically motivating. It is believed that these elements tap in to human nature, and attract people to gaming.<sup>38</sup> Gamification, the integration of gaming elements, mechanics, and frameworks into non-game situations and scenarios has been useful for training and for motivational behavioural purposes. For example, the National Society for Road Safety in Sweden found that when gamification was introduced in cars, more drivers observed speed limits.<sup>39</sup> In Nordic schools, the gamification of learning environments is gaining support among educators who recognise that effectively designed games can stimulate large gains in engagement, productivity, creativity, and authentic learning.

### Relevance for Teaching, Learning, or Creative Inquiry

- Discovery-based and goal-oriented learning is often inherent in educational games, fostering development of social skills such as collaboration and teamwork.
- Gamified learning environments help students keep track of new skills as they gain them and motivate learners to pursue the next level of mastery.
- Simulations and role-playing games allow students to experience real-world challenges with room to try new, creative solutions and to learn from failures.

### Games and Gamification in Practice

- At Skt Josef International School in Denmark, a teacher reported success using digital games such as Minecraft Edu and OneNote to teach her primary students math: [go.nmc.org/sktjosef](http://go.nmc.org/sktjosef).
- Educators in Norway take the lecture style traditionally used when teaching literature and apply it to video games. After playing games in class, students participate in a discussion-based reflection on the choices that the characters made. This activity encourages authentic conversations about society and real-world decision-making: [go.nmc.org/grieg](http://go.nmc.org/grieg).
- eSports students in Sweden replace traditional physical education with classes on the tactics and strategy of gaming: [go.nmc.org/esports](http://go.nmc.org/esports).
- A Viktor Rydberg school teacher in Sweden introduced Minecraft as a means of teaching students about city planning and environmental issues: [go.nmc.org/rydberg](http://go.nmc.org/rydberg).

### For Further Reading

*Computer Games at School*

[go.nmc.org/iktsenteret](http://go.nmc.org/iktsenteret)

(Jorund Hoie Skaug et al., Centre for ICT in Education, November 2014.) This paper highlights the need for teachers to make strong connections between games and the learning material when gamifying assignments and lesson plans.

*Will Computer Games in School Become Less Scary?*

[go.nmc.org/Siguroardottir](http://go.nmc.org/Siguroardottir)

(Lynne Olav Leknes, research.no, August 2016.) An educational gaming researcher asserts that the media's perception of video games as violent and a waste of time has waned, making room for more constructive and important advancements in education-based gamification.

## Time-to-Adoption: One Year or Less

### Makerspaces

Primary and secondary education is increasingly focused on methods to foster the development of 21<sup>st</sup> century skills in students, preparing them for the demands of the global technological economy.<sup>40</sup> To address these needs of the future, a growing number of community centres and classrooms are being transformed into makerspaces, physical environments that offer tools, technologies, and opportunities for hands-on learning and creation. The Library for Children and Young Adults in Oslo, Norway, for example, welcomes visitors to its makerspace Folkeverksetet for participation in open collaboration, programming, and a production workshop.<sup>41</sup> As maker culture expands, educators are leveraging makerspaces and maker activities as a method for engaging learners in higher-order problem-solving through design, construction, and iteration.<sup>42</sup> Incorporating making into the curriculum is encouraging both students and teachers to bring to life ideas and explore design thinking approaches. Learners are also applying these new skills to address some of the world's pressing challenges by building innovative solutions.<sup>43</sup>

### Relevance for Teaching, Learning, or Creative Inquiry

- Makerspaces equipped with technologies and construction supplies are all-purpose workshops that represent the power of creation in both the virtual and physical world.
- Makerspaces that can be accessed outside of scheduled classes provide a place for school faculty and students to pursue making activities on their own or participate in extracurricular camps that promote design skills with a variety of tools.
- Pedagogies such as inquiry-based learning and design thinking, which require learners to think like engineers by encouraging planning, construction, and delivery, can be carried out in makerspaces.

### Makerspaces in Practice

- In Norway, students experience interactive, hands-on approaches to learning about computers and electronics through makerspace activities: [go.nmc.org/skogmo](http://go.nmc.org/skogmo).
- Researchers in Denmark examined how makerspaces at the International School of Billund contribute to primary school students' 21<sup>st</sup> century skill development through exploration and play: [go.nmc.org/ibs](http://go.nmc.org/ibs).
- A Swedish teacher shares lessons from her makerspace-inspired classroom, where her students use Strawbees to bring their ideas to physical form: [go.nmc.org/strawb](http://go.nmc.org/strawb).

### For Further Reading

*4 Steps to Planning a Successful Makerspace*

[go.nmc.org/4stepplan](http://go.nmc.org/4stepplan)

(Tanya Roscorla, Centre for Digital Education, 5 July 2016.) The author highlights the need to create an authentic makerspace that fits the needs of the community it serves and provides four recommendations for doing so.

*Finnish Educators Seek Closer Look at FUSE Programme*

[go.nmc.org/fuses](http://go.nmc.org/fuses)

(Julie Deardorff, *Northwestern News*, September 2016.) Researchers from Finland's Playful Learning Center are visiting a US institution's FUSE Studio to inform design and construction of three new FUSE studios, soon to arrive in two Helsinki schools.

*Stories from Sweden: Makerspace in School (Video)*

[go.nmc.org/storiesfrom](http://go.nmc.org/storiesfrom)

(Carl Heath, Recorded at Maker Ed, 23 May 2016.) A senior researcher at Interactive Institute Swedish ICT gives a lecture on Makerskola, a project funded by Vinnova that aims to introduce maker culture and programming throughout the Swedish education system.

## Time-to-Adoption: One Year or Less

### Mobile Learning

The pervasiveness of mobile devices is changing the way humans interact with information and their surroundings. Smartphone device ownership alone is almost universal in Nordic countries,<sup>44</sup> and smart devices, including phones, tablets, and watches, are now capable of acting as miniaturised computers; their storage space and processing power has increased dramatically with each subsequent release. Mobile learning, or m-learning, leverages this technology to make learning portable, meaning a learner can access materials virtually anywhere. The first wave of m-learning came in the form of apps, which are small, low-cost software extensions to devices. Proving to be a hotbed of development, a vast range of educational apps has been created, including language learning apps and math and science tutorials. Mobile apps have been adopted by Nordic schools to spur more immersive learning, especially as Bring Your Own Device and 1:1 models have grown. Funzi, a Finnish startup, is investigating how mobile learning can provide services that result in immediate student impact, developing features that empower collaboration while encouraging the cultivation of new knowledge and skills.<sup>45</sup> Over time, m-learning will continue to gain traction in primary and secondary education because it enables people to learn and experience new concepts wherever they are, often across multiple devices.

### Relevance for Teaching, Learning, or Creative Inquiry

- As a 1:1 solution, mobiles present an economic, flexible alternative to laptops and desktops due to the devices' lower cost, greater portability, and access to apps.
- Mobile apps with built-in social features enable learners to share their questions or findings with each other in real time.
- Students can leverage the cameras, microphones, and other tools inherent in mobiles to do fieldwork or create rich media. This is especially convenient for work done outside of the classroom as students can record interviews, collect data for experiments, and more.

### Mobile Learning in Practice

- Dyslexic students in Aarhus Danish schools use Surface Pro 2 to improve their reading skills, with assistive content right at their fingertips: [go.nmc.org/aarhus](http://go.nmc.org/aarhus).
- In Norway, a principal implements a 1:1 Chromebook program for 6<sup>th</sup> grade students, allowing students to access valuable class materials from home: [go.nmc.org/asker](http://go.nmc.org/asker).
- Through an Environmental Education Project, Finnish students used mobile app Citynomadi to study their surrounding landscape: [go.nmc.org/juupajoki](http://go.nmc.org/juupajoki).

### For Further Reading

*Bring Your Own Device: A Guide for School Leaders (PDF)*

[go.nmc.org/guidefor](http://go.nmc.org/guidefor)

(Jill Attewell, European Schoolnet, October 2015.) As part of their Future Classroom Lab, this report examines the growing landscape of BYOD case studies across European schools, landing on 15 best practices for this approach. Tips include polling students about what devices they use and making m-learning accessible to learners with special needs.

*Every Third Student in Primary School Brings their Own IT Equipment*

[go.nmc.org/it](http://go.nmc.org/it)

(Andreas Brons Riise, *folkeskolen*, August 2014.) This article details key challenges and watch-outs to ensure productive use of mobile learning in the classroom.

*Mobile Learning and Content Creation for Location-Based Learning Applications*

[go.nmc.org/tampere](http://go.nmc.org/tampere)

(Katariina Tiitinen, Master's Thesis, June 2015.) This research paper presents observations and suggested product improvements from a field experiment in which Finnish students used location-based mobile app Seek'N'Share to complete a series of assignments.



## Time-to-Adoption: Two to Three Years

### Adaptive Learning Technologies

Adaptive learning technologies refer to software and online platforms that adjust to individual students' needs as they learn. Adaptive learning is a "sophisticated, data-driven, and in some cases, nonlinear approach to instruction and remediation, adjusting to a learner's interactions and demonstrated performance level, and subsequently anticipating what types of content and resources learners need at a specific point in time to make progress."<sup>46</sup> Many educators envision adaptive learning platforms as patient tutors that can provide personalised instruction on a large scale. There are two levels to these adaptive learning technologies — the first platform reacts to individual user data and adapts instructional material accordingly, while the second leverages aggregated data across a large sample of users for insights into the design and adaptation of curricula. This aggregate use of data is spurring discussions about the ethics of using personal data. To address this complex issue, the Norwegian government has established the Centre for Science of Learning and Technology to address the balance between national policies and the local use of tools and educational methods.<sup>47</sup>

### Relevance for Teaching, Learning, or Creative Inquiry

- Adaptive learning dashboards are often viewable by students so they can gain a better understanding of what habits and activities are helping them learn more effectively.
- Adaptive learning technologies link specific concepts and skills to how students are interacting with the material, signalling algorithms to offer more resources when they need help better comprehending the subject matter.
- If applied effectively, adaptive learning can foster more personalised learning for students while providing institutions with key insights about the efficacy of their instruction.

### Adaptive Learning Technologies in Practice

- CampMat is a new digital program that uses a gamified adaptive learning environment to teach Danish primary school students math; students receive gifts when they have mastered a task, before moving on to higher-level activities: [go.nmc.org/campmat](http://go.nmc.org/campmat).
- Finnish company Claned received the Worlddidac Award for its products, which leverage artificial intelligence to deliver personalised learning experiences, recommend study materials, and mentor students to best meet their individual needs: [go.nmc.org/claned](http://go.nmc.org/claned).
- Jar school in Baerum is among one of the first in Norway to use adaptive learning; so far they have found it to be a useful balance between challenging students and engaging them in ways that are familiar to them: [go.nmc.org/baerum](http://go.nmc.org/baerum).

### For Further Reading

*Adaptive and Interactive Learning Takes More than Hardware to Succeed*

[go.nmc.org/nordicstartup](http://go.nmc.org/nordicstartup)

(Lisa Mallner, *Nordic Startup Bits*, April 2016.) This article highlights the importance of a learning-first approach, teaching training tools, and intensive software evaluation for new adaptive learning technologies to reach their potential in the classroom.

*Personalised Learning: The Conversations We're Not Having (PDF)*

[go.nmc.org/primer](http://go.nmc.org/primer)

(Monica Bulger, *Data & Society*, 22 July 2016.) Personalised learning (PL) is an important outcome of adaptive learning. This paper defines the boundaries of PL and highlights the tensions between what is being promised and the practical realities of implementation.

*Perspectives on Adaptive/Personalised Learning*

[go.nmc.org/adaptive](http://go.nmc.org/adaptive)

(Eilif Trondsen, *Nordic Edtech Network*, January 2016.) A commentary summarises the rise of adaptive learning and an overview of Nordic companies and solutions in the field.

## Time-to-Adoption: Two to Three Years

### Artificial Intelligence

In the field of artificial intelligence (AI), computer science is being leveraged to create intelligent machines that more closely resemble humans in their functions.<sup>48</sup> AI can revolutionise the way all industries operate. This technology is projected to double the economic growth rate in Finland and Sweden by 2035, raising labour productivity by 36% and 37% respectively.<sup>49</sup> The knowledge engineering that allows computers to simulate human perception, learning, and decision-making is based on access to categories, properties, and relationships between various information sets. Machine learning (also called deep learning) is a subset of AI, providing computers the ability to learn without being explicitly programmed.<sup>50</sup> As another significant area of research, neural networks are proving valuable for more sophisticated natural user interfaces through voice recognition and natural language processing, allowing humans to interact with machines similarly to how they interact with each other. Neural networks model the biological function of human brains to interpret and react to specific inputs such as words and tone of voice.<sup>51</sup> As the underlying technologies continue to develop, AI has the potential to enhance online learning, adaptive learning software, and research processes in ways that more intuitively respond to and engage with students.

### Relevance for Teaching, Learning, or Creative Inquiry

- Machine learning models can potentially sort through learner-contributed observations about the world around them and create visualisations that identify crucial patterns.
- Software that employs machine learning to detect patterns in written work, speech, and other actions could better adapt to students' learning styles and needs.
- Ultimately, artificial intelligence will be able to use machine learning to act as a humanlike personalised coach for various pedagogical subjects.

### Artificial Intelligence in Practice

- At Frederiksvaerk school in Denmark, teachers and students are enthusiastic about the use of SmartBooks, a digital tutor that leverages AI, tailoring individual student learning paths based on students' reading comprehension following each assignment: [go.nmc.org/fred](http://go.nmc.org/fred).
- A Danish high school received a visit from an IT specialist and a Japanese artificial intelligence robot, spurring a discussion about AI's ethical implications: [go.nmc.org/ags](http://go.nmc.org/ags).
- More than 25 Swedish schools are using Education Albert, a learning solution that uses machine learning algorithms to power Mr Albert, an AI math tutor who delivers personalised lessons to students: [go.nmc.org/mralbert](http://go.nmc.org/mralbert).

### For Further Reading

*Artificial Intelligence and Classrooms: Will It Help or Hurt?*

[go.nmc.org/helpor](http://go.nmc.org/helpor)

(Matthew Lynch, *Education Week*, 28 March 2016.) This article discusses the benefits of AI in primary and secondary education, including one-on-one tutoring and customised learning modules, but also raises concerns about inadvertently lowering the quality of teaching.

*Artificial Intelligence that Mimics Children's Learning*

[go.nmc.org/aimimic](http://go.nmc.org/aimimic)

(Catharina Jerkbrant, Chalmers, October 2014.) Researchers at a Swedish university are creating technologies that can imitate and authentically respond to children's learning.

*Swedish Parliamentary Breakfast Focused on EdTech: Question & Answers*

[go.nmc.org/trondsen](http://go.nmc.org/trondsen)

(Eilif Trondsen, Nordic Edtech Network, January 2016.) In this interview, the Silicon Vikings Chair reveals that artificial intelligence and machine learning will drive the next great advances in adaptive learning.

## Time-to-Adoption: Two to Three Years

### Mixed Reality

At the intersection of virtual and physical realities is an emerging environment known as mixed reality (MR). This seamless integration of virtual technologies into the real world is made possible by devices equipped with 3D viewing technology that layers digital objects onto the physical environment.<sup>52</sup> A major component of MR is the integration of augmented reality (AR), the layering of information over 3D space. A key characteristic of AR is its ability to respond to user input, which confers significant potential for learning and assessment; learners can construct new understanding based on interactions with virtual objects that bring underlying data to life. Holographic devices are also being used to create mixed reality environments by using video displays to project 3D images into a physical space. In Norway, winners of the 2016 Hack4Norden competition developed Hidden, a map-based gaming app that uses AR to preserve Nordic heritage by incorporating folkloric stories into the physical locations they are connected to.<sup>53</sup>

### Relevance for Teaching, Learning, or Creative Inquiry

- By connecting events and educational activities to the physical environment, mixed reality can bring exportation and story-telling to the classroom.
- Complex concepts in subjects such as anatomy, chemistry, and biology can be easier to understand when using mixed reality to provide students with a visual connection between textbook information and the real world.
- Mixed reality fosters more immersive classroom interactions, such as experiencing ancient civilisations and seascapes, allowing students to engage with locales and concepts that they would not be able to access in the physical realm.

### Mixed Reality in Practice

- Danish fourth graders combined art and urban space by using iPads and the mixed reality app Aurasma to create virtual graffiti across town. The lesson launched a discussion on ethics, copyright, and public space: [go.nmc.org/fjel](http://go.nmc.org/fjel).
- A Swedish high school's use of AR-simulated science education made learning materials more affordable, with the lessons becoming more efficient and dynamic by replacing the need for expensive lab equipment: [go.nmc.org/sshl](http://go.nmc.org/sshl).
- Teachers at Vastra Ramlosa in Sweden brought education outdoors when field testing Minnesmark, a new mixed reality mobile platform that allows educators to drop virtual objects on a location, bringing students on a learning treasure hunt: [go.nmc.org/minnes](http://go.nmc.org/minnes).

### For Further Reading

*Augmented Reality in Science Education: Affordances for Student Learning*

[go.nmc.org/nsse](http://go.nmc.org/nsse)

(Birgitte Lund Nielsen et al, *Nordic Studies in Science Education*, December 2016.) The authors highlight the importance of “learning before technology,” and present a framework for understanding to what extent AR design can be leveraged in the classroom.

*Digital Learning with Augmented Reality*

[go.nmc.org/edu21](http://go.nmc.org/edu21)

(Edu21, October 2014.) This post discusses using mixed reality in primary education, augmented reality product reviews, and live demos of mixed reality technologies in use.

*Making the Invisible Observable by Augmented Reality in Informal Science Education Context*

[go.nmc.org/ijse](http://go.nmc.org/ijse)

(Hannu Salmi, *International Journal of Science Education*, May 2016.) A study found that using AR in a STEM-education experiment led to positive academic performance for all Finnish students in the test, but particularly for the lowest-achieving group and for girls.

## Time-to-Adoption: Two to Three Years

### Robotics

Robotics refers to the design and application of robots — automated machines that accomplish a range of activities. The first robots were integrated into factory assembly lines in order to streamline and increase the productivity of manufacturing, most notably for cars. Today, the role of robots in mining, transportation, and the military has helped improve operations for industries as they perform tasks that are unsafe or tedious for humans.<sup>54</sup> The global robot population is expected to double to four million by 2020, a shift that will impact business models and economies worldwide,<sup>55</sup> with a projected market value of \$135 billion in 2019.<sup>56</sup> While robotics is two to three years away from mainstream adoption in primary and secondary education, potential uses are gaining traction for hands-on learning, particularly in STEM disciplines. Classes and outreach programmes are incorporating robotics and programming to promote critical and computational thinking as well as problem-solving among students. Emerging studies also show that interaction with humanoid robots can help learners with spectrum disorders develop better communication and social skills.<sup>57</sup> In Denmark, two robotics companies, Kubo Robot and Blue Ocean Robotics, are designing a new educational robot, Kubo Junior, intended to help young people learn coding.<sup>58</sup>

### Relevance for Teaching, Learning, or Creative Inquiry

- For students with social anxieties, robots can be a more comfortable means of educational interaction and instruction than traditional methods.
- Robot programming can act as a hands-on way to facilitate creative problem-solving, collaboration, and critical thinking in the classroom.
- With the help of sophisticated machine learning, robots can act as valuable adaptive learning solutions, tailoring instruction to fit each student's needs.

### Robotics in Practice

- In Svendborg, Denmark, Robot Zeno acts as a classroom aid for students with special needs and disabilities, such as Asperger's and autism: [go.nmc.org/zeno](http://go.nmc.org/zeno).
- Skagen School in Denmark piloted a new multidisciplinary course that combines science, technology, and math by teaching students how to program robots: [go.nmc.org/skagen](http://go.nmc.org/skagen).
- A small robot from the Norwegian startup «No Isolation» attends school as an avatar on behalf of children with long-term illness. The robot is already in use in several schools in Norway, connecting young users to friends over mobile broadband and Wi-Fi — even at birthday parties and other social activities: [go.nmc.org/noiso](http://go.nmc.org/noiso).
- Zero Robotics launched a competition in which secondary school students from Nordic and other countries were challenged to build and operate robots with the express purposes of completing specific tasks: [go.nmc.org/zeror](http://go.nmc.org/zeror).

### For Further Reading

*Ideas for School: Robots*

[go.nmc.org/okolariet](http://go.nmc.org/okolariet)

(Okolariet, Knowledge, Robots, accessed 9 January 2017.) This online resource by the Danish science museum Okolariet provides inspiration and lesson plans for incorporating robotics in classroom settings.

*Kids Teaching Robots: Is this the Future of Education?*

[go.nmc.org/kidst](http://go.nmc.org/kidst)

(Chris Berdik, *The Hechinger Report*, 29 April 2015.) The author explores a future learning landscape where students teach robots in order to actively demonstrate their knowledge acquisition and improve their higher-order thinking.

## Time-to-Adoption: Four to Five Years

### Speech-to-Speech Translation

No longer in the realm of science fiction, the concept of a real-time universal translator is currently in the works as pioneering companies such as Google and Facebook are acquiring and developing technologies that support speech recognition, language translation, and speech synthesis. In 2006, an advancement that led to the development and use of layered models of inputs, termed deep neural networks (DNN), brought speech recognition to its highest level of accuracy yet, clearing the way for speech-to-speech translation. Researchers have since applied DNN to automatic translation engines, paving the way for new companies to optimise real-life conversations such as the crowd-funded SpeechTrans, which makes over-the-phone live translations possible. Similar technologies will be able to assist people in medical crisis or other emergency situations.<sup>59</sup> Experts believe that by 2030, machines will have sufficient enough understanding of oral and written communication to deliver daily translations that are highly accurate and eloquent.<sup>60</sup> This industry is in its nascent stages, especially for formal education, because there are still many challenges to making this technology ubiquitous.<sup>61</sup> However, Nordic educators may soon see more pedagogical research on speech-to-speech translation as well as methods for leveraging it to enable multilingual learning in the classroom.

### Relevance for Teaching, Learning, or Creative Inquiry

- As speech-to-speech translation continues to advance, it is opening up a world of new learning resources as both teachers and students are able to access videos and podcasts in other languages that they previously would not have been able to comprehend.
- More sophisticated translation tools are improving virtual assistants, enabling voice-activated services like Cortana and Siri to be more effective in responding to teachers' and students' searches and requests.
- Speech-to-speech translation can allow students to participate in global projects and build relationships with peers from other countries by removing language barriers to communication.

### Speech-to-Speech Translation in Practice

- After three years of missing school, a Syrian boy completes his first semester in a new school in Canada. Like many refugee families using apps like Google Translate and SayHi, his parents leverage speech-to-speech translation technology to help them navigate life in a new country where they do not speak the local language: [go.nmc.org/syria](http://go.nmc.org/syria).
- The latest release of Microsoft Translator now encompasses a speech translation API for eight languages to better capture real-life conversations: [go.nmc.org/stapi](http://go.nmc.org/stapi).
- The recently released Pilot leverages speech-to-speech translation technology to enable multilingual conversations by providing translations through a wearable earpiece: [go.nmc.org/pilot](http://go.nmc.org/pilot).

### For Further Reading

*How to do Speech Recognition with Deep Learning*

[go.nmc.org/howtodo](http://go.nmc.org/howtodo)

(Adam Geitgey, *Medium*, 23 December 2016.) The author seeks to make the programming behind speech-to-speech translation more transparent, providing illustrations to showcase best practice processes in a manner that is easier to understand.

*Language: Finding a Voice*

[go.nmc.org/findinga](http://go.nmc.org/findinga)

(Lane Greene, *The Economist*, 5 January 2017.) While there have been great strides made in machine translation, voice recognition, and speech synthesis, there are still challenges in capturing the nuances of language to more accurately translate human conversation.

## Time-to-Adoption: Four to Five Years

### Virtual and Remote Laboratories

Virtual and remote laboratories reflect a movement among schools to make the equipment and elements of a physical science laboratory more easily available to learners from any location, via the web. Virtual laboratories are web applications that emulate the operation of real laboratories through virtual technical interaction and direct and plausible manipulation of objects and parameters.<sup>62</sup> They also enable students to practice in a safe environment before using real, physical components. Some emerging virtual lab platforms incorporate reporting templates that populate with the results of the experiments so that students and teachers can easily review the outcomes. Remote laboratories, on the other hand, provide a virtual interface to a real, physical laboratory. Institutions that do not have access to high-calibre lab equipment can run experiments and perform lab work online, accessing the tools from a central location. Users are able to manipulate the equipment and watch the activities unfold via a webcam on a computer or mobile device. This provides students with a realistic view of system behaviour and allows them access to professional laboratory tools from anywhere, whenever they need. Educators across the Nordics are adopting these new technological approaches to learning science. In Denmark, 20% of high schools are currently using Labster's "The Virtual," an interactive, virtual 3D platform for learning science and running experiments.<sup>63</sup> Research has shown that students experience higher learning effectiveness and higher motivation when using Labster, relative to traditional means.<sup>64</sup>

### Relevance for Teaching, Learning, or Creative Inquiry

- Because virtual laboratories do not involve real equipment or chemicals, students feel more comfortable making mistakes and run experiments in complete safety.
- Teachers play back videos of the experiments students have run online, pinpoint areas for improvement or further discussion, and acknowledge students who have excelled.
- Virtual and remote laboratories make access to science tools ubiquitous, allowing learners to use them via wireless or cellular networks at home, on school busses, and at libraries.

### Virtual and Remote Laboratories in Practice

- Danish university students developed Biotech Academy's Virtual Laboratory 2.0, which is free to high schools and has been used to conduct virtual laboratory experiments, including detergent enzyme testing, antibody and vaccine testing, and insulin modification treatment for diabetes: [go.nmc.org/vlab2.0](http://go.nmc.org/vlab2.0).
- In Finland, Kuopio High School students are familiarising themselves with 360-cameras and virtual glasses in preparation for new virtual laboratory experiments: [go.nmc.org/yle](http://go.nmc.org/yle).
- The Go-Lab project is a European collaborative that provides access to remote and virtual labs through an online repository: [go.nmc.org/golab](http://go.nmc.org/golab).
- Students at a Finnish high school collaborated with US Finnish universities to conduct a virtual lab experiment studying the effects of climate change on salmon. The project revealed that virtual lab support is crucial to student success: [go.nmc.org/ugoth](http://go.nmc.org/ugoth).

### For Further Reading

#### *4 Benefits of Virtual Labs*

[go.nmc.org/4ben](http://go.nmc.org/4ben)

(Matthew Lynch, *The Edvocate*, 23 April 2016.) Flexible access, instant feedback, top notch equipment, and lower costs are among the positive gains for schools using virtual labs.

#### *This Virtual Lab Will Revolutionise Science Class (Video)*

[go.nmc.org/revol](http://go.nmc.org/revol)

(Michael Bodekaer, TED Talks, October 2015.) A TED Talk from the Swiss entrepreneur who founded Labster reveals the next incarnation of virtual labs, which leverage virtual reality to provide more immersive science learning experiences for students.

## Time-to-Adoption: Four to Five Years

### Virtual Assistants

As voice recognition and gesture-based technologies advance and converge, we have moved away from the notion of interaction with our devices via a pointer and keyboard. Virtual assistants are the end goal of natural user interfaces, and build on developments in interfaces across the spectrum of engineering, computer science, and biometrics. Advancements in image recognition have added another layer, now making it possible for computers to analyse and describe a visual. In fact, a study found that one in four people preferred a description made by a computer to one made by a man.<sup>65</sup> Simple mobile and household virtual assistants such as Apple's Siri and Amazon's Alexa have entered the consumer marketplace, making the technology accessible to people globally. It is estimated that two billion people will be using virtual assistants by 2021.<sup>66</sup> Virtual assistants are also becoming integral to Nordic businesses like Swedbank, a financial institution that now resolves 78% of queries upon first contact with their virtual assistant, Nina.<sup>67</sup> Soon, virtual assistants could be used for babysitting and caring for the elderly.<sup>68</sup> In the not too distant future, virtual assistants will begin appearing more frequently in Nordic classrooms, acting as personalised learning aids for students in the form of chatbots and virtual tutors.

### Relevance for Teaching, Learning, or Creative Inquiry

- Teachers are able to spend more of their attention on student learning by utilising virtual assistants to complete classroom administrative tasks.
- Virtual assistant platforms can be controlled remotely, allowing students to participate in lectures and school activities despite mobility constraints.
- With the help of voice recognition and artificial intelligence, virtual assistants can act as patient tutors, quizzing students on newly acquired knowledge as they prepare for exams.

### Virtual Assistants in Practice

- At BI Norwegian Business School, teachers find students are engaging more deeply with course material by using chatbots to get immediate answers to their questions. The next iteration of this technology will be the result of a partnership between IBM and Pearson to leverage Watson: [go.nmc.org/bi](http://go.nmc.org/bi).
- Cognii announced the launch of a virtual learning assistant that uses artificial intelligence and natural language processing technologies to provide students with adaptive tutoring. The platform will be able to answer student inquiries and measure students' critical thinking, coaching them towards mastery of subject matter: [go.nmc.org/cognii](http://go.nmc.org/cognii).
- A National Science Foundation research project will create a scalable virtual assistant that can bring innovative and usually expensive technology to schools at an affordable price: [go.nmc.org/nsfr](http://go.nmc.org/nsfr).

### For Further Reading

*6 Ways Students Can Use Siri*

[go.nmc.org/siri](http://go.nmc.org/siri)

(Kimberly Kellogg, *simpleK12*, 22 August 2015.) This post includes ways in which students can use Apple's voice-recognition product Siri as a resource aid, including visualisation of complex concepts and dictation of notes.

*A Step Closer to Robotic Tutors for the Classrooms*

[go.nmc.org/astep](http://go.nmc.org/astep)

(*Neuroscience News*, October 2016.) The convergence of robotics, artificial intelligence, and tutoring may be on the horizon for schools with virtual assistants that recognise and respond to a spectrum of human emotions. For example, the tutoring platform MONICA integrates educational software Scratch into a robot that guides children in their learning. Students participating in a trial with MONICA felt more relaxed in its presence.

## Time-to-Adoption: Four to Five Years

### Wearable Technology

Wearable technology refers to smart devices that can be worn by users, taking the form of an accessory such as jewellery or eyewear. Smart textiles also allow items of clothing such as shoes or jackets to interact with other devices. Head-mounted wearable displays such as Oculus Rift and Google Cardboard facilitate immersive virtual reality (VR) experiences.<sup>69</sup> It is believed that by 2020, 80% of the VR glasses actively being used will make it difficult to distinguish VR from the real world.<sup>70</sup> Wearable devices also have great potential in the healthcare industries, as they can monitor patient vital signs. In Sweden, scientists are developing ways to power wearable devices through blood in order to inform medical applications.<sup>71</sup> Well-positioned to advance the quantified self-movement, today's wearables not only track where people go, what they do, and how much time they spend doing it, but now what their aspirations are and when those can be accomplished.<sup>72</sup> This category also has potential to interest a variety of students in STEAM learning, as classroom activities can encompass multidisciplinary efforts of design, building, and programming.<sup>73</sup>

### Relevance for Teaching, Learning, or Creative Inquiry

- GoPro devices can be worn anywhere to capture constant images, enabling students to track their surroundings automatically — a particularly interesting dimension for student field trips or conducting science experiments.
- Students already spend time in formal classroom settings gathering data about themselves or research topics they have been assigned. Quantified, self-enabled wearables tap into this interest to make the data collection process much easier.
- Wearable fitness technologies, which often have heart rate and step-tracking monitors, can provide a unique game-focused way to engage students in physical education.

### Wearable Technology in Practice

- Google selected Denmark as one of its testing locations for Google Expeditions, its wearable technology program that takes students on geographic world tours through virtual reality: [go.nmc.org/exped](http://go.nmc.org/exped).
- Hoping to inspire the next generation of programmers, the BBC is distributing Micro Bits to schools across the UK; students will learn to program these Micro Bits into wearable devices: [go.nmc.org/microb](http://go.nmc.org/microb).
- Seeing what it calls Wearable-Enhanced Learning (WELL) on the horizon, the European Association for Technology Enhanced Learning is hosting a special WELL-focused track at its next annual iLRN conference: [go.nmc.org/well](http://go.nmc.org/well).

### For Further Reading

*Magic Leap Goes to Finland in Pursuit of Nordic VR and AR Talent*

[go.nmc.org/mleap](http://go.nmc.org/mleap)

(Dennis Mitzner, TechCrunch, 28 October 2016.) Magic Leap recently established a company in Helsinki presumably to recruit the gaming-focused AR hardware and software talent that Finland is well-known for. The company's wearable technology capabilities are frequently displayed using interactive solar system and animal scenes.

*Wearable Technology and Schools: Where are We and Where Do We Go from Here?*

[go.nmc.org/wearwhere](http://go.nmc.org/wearwhere)

(Brian K. Sandall, *Journal of Curriculum, Teaching, Learning, and Leadership in Education*, May 2016.) Presenting an overview of how wearable technology is being introduced into teaching and learning, this article then takes a deeper look at the challenges schools must address to leverage the technology in pedagogically meaningful ways.



## Methodology

The process used to research and create the *2017 NMC Technology Outlook for Nordic Schools: A Horizon Project Regional Report* is very much rooted in the methods used throughout the NMC Horizon Project. All publications of the NMC Horizon Project are produced using a carefully constructed process that is informed by both primary and secondary research. Dozens of technologies, meaningful trends, and critical challenges are examined for possible inclusion in the report for each edition. Every report draws on the considerable expertise of an internationally renowned panel of experts that first considers a broad set of important emerging technologies, challenges, and trends, and then examines each of them in progressively more detail, reducing the set until the final listing of trends, challenges, and important developments in technology is selected.

Much of the process takes place online, where it is captured and placed in the NMC Horizon Project wiki. This wiki, which has grown into a resource of hundreds of pages, is intended to be a completely transparent window onto the work of the project, and contains the entire record of the research for each of the various editions. The section of the wiki used for the *2017 NMC Technology Outlook for Nordic Schools* can be found at [nordic.wiki.nmc.org](http://nordic.wiki.nmc.org).

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

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

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

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

- c. *What are the important developments in technology you see developing to the point that Nordic schools and programmes should begin to take notice during the next four to five years?*
3. *What key trends do you expect to have a significant impact on the ways in which Nordic schools and programmes approach our core missions of teaching, learning, and creative inquiry?*
4. *What do you see as the significant challenges related to teaching, learning, and creative inquiry that Nordic schools and programmes will face during the next five years?*

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

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

For additional detail on the project methodology or to review the instrumentation, the rankings, and the interim products behind the report, please visit the project wiki which can be found at [nordic.wiki.nmc.org](http://nordic.wiki.nmc.org).



## 2017 Horizon Project Nordic Expert Panel

**Samantha Adams Becker**  
Co-Principal Investigator

New Media Consortium  
United States

**Jakob Harder**  
Editorial Board

National Agency for IT and Learning  
Denmark

**Johnny Andersson**

National Agency for Special Needs  
Education and Schools  
Sweden

**Marianne Barland**

Norwegian Board of Technology  
Norway

**Peter Becker**

Datorn i Utbildningen  
Sweden

**Lina Simone Bergström**

Silkeborg municipality, school department  
Denmark

**Sven Olaf Brekke**

Odda lower secondary school  
Norway

**Anna Carlsson**

Swedish Association of Local Authorities  
and Regions (SKL)  
Sweden

**Martin Claesson**

Stockholm City  
Sweden

**Liv Klakegg Dahlin**

Oslo and Akershus University College of  
Applied Science  
Norway

**Magdi Engelstoft el-Toukhy**

Hippomini  
Denmark

**Ola Erstad**

University of Oslo  
Norway

**Ellen Kathrine Fossvoll**

Norwegian University of Science and  
Technology  
Norway

**Dorte Frstrup**

Aarhus Statsgymnasium / Youth Education  
Council  
Denmark

**Rurik Greenall**

NTNU University Library  
Norway

**Nikolaj Grønning Hansen**

Alinea Digital Learning  
Denmark

**Carl Heath**

Göteborg  
Sweden

**Morten Søyby**

Co-Principal Investigator

Norwegian Centre for ICT in Education  
Norway

**Trond Ingebretsen**  
Editorial Board

Norwegian Centre for ICT in Education  
Norway

**Ole Sejer Iversen**

University of Aarhus  
Denmark

**Øystein Johannesen**

Nordland County  
Norway

**Susanne Kjällander**

Stockholm University  
Sweden

**Camilla Kølсен**

Alexandra Institute  
Denmark

**Helena Kvarnsell**

Nacka  
Sweden

**Markku Lang**

University of Oulu  
Finland

**Lars Lingman**

Skolverket  
Sweden

**Liselotte Lyngsø**

Future Navigator  
Denmark

**Helle Mathiasen**

University of Copenhagen  
Denmark

**Ingrid Melve**

UNINETT (Norwegian Research and  
Education Network)  
Norway

**Ann S. Michaelsen**

Sandvika upper secondary school  
Norway

**Johan Nordberg**

Digitalt hjärta  
Sweden

**Karin Nygårds**

Sjöstadskolan school  
Sweden

**Jouni Paakkinen**

City of Turku  
Finland

**Stefan Pålsson**

Malmö  
Sweden

**Kirsten Pantou**

Microsoft  
Denmark

**Michele Cummins**

Horizon Project Operations

New Media Consortium  
United States

**Peter Karlberg**  
Editorial Board

Swedish National Agency for Education  
Sweden

**Lars Persen**

Scandec systemer  
Norway

**Niels Hjort Petersen**

Fredericia Municipality  
Denmark

**Ylva Pettersson**

Skara  
Sweden

**Kristine Ploug**

DADIU (Danish Academy for Digital,  
Interactive Entertainment)  
Denmark

**Lasse Remmer**

University College in Copenhagen  
Denmark

**Stefan Reppe**

Trondheim kommune  
Norway

**Jette Risgaard**

Atea - Nordic IT company  
Denmark

**Hans Petter Røkholt**

Conexus  
Norway

**Tero Rynkä**

Ubiikki OY  
Finland

**Morgens Sandfaer**

Technical University of Denmark  
Denmark

**Tiina Sarisalmi**

City of Orivesi  
Finland

**Marie Tängdén**

Skolverket  
Sweden

**Torben Stolten Thomsen**

Hansenberg  
Denmark

**Olli Vesterinen**

Diaconia University of Applied Sciences  
Finland

**Ingrid Somdal-Åmodt Vinje**

Abelia  
Norway

**Barbara Wasson**

SLATE University of Bergen  
Norway

## End Notes

- <sup>1</sup> <https://www.regjeringen.no/en/aktuelt/proposal-for-renewal-and-improvement-of-school-subjects/id2483423/>
- <sup>2</sup> <http://edtechfuture-talk.blogspot.com/2016/05/3d-as-accelerator.html>
- <sup>3</sup> [http://yle.fi/uutiset/osasto/news/coding\\_soon\\_to\\_be\\_part\\_of\\_finnish\\_schoolchildrens\\_core\\_curriculum/7818567](http://yle.fi/uutiset/osasto/news/coding_soon_to_be_part_of_finnish_schoolchildrens_core_curriculum/7818567)
- <sup>4</sup> As of autumn 2016, Finland is one of the first EU countries to introduce 'algorithmic thinking' (algoritminen ajattelu) and programming as a mandatory, cross-curricular activity from the first year of school (grade 1). The new National Core Curriculum for primary and lower secondary schools was published in 2014 and foresees implementation between August 2016 and August 2018.
- In Denmark, Computational Thinking (CT) is not a separate topic in K-9, but IT and media is integrated across subjects in primary and lower secondary education. IT and media includes skills such as problem-solving and logical thinking, but not all key CT characterisations. It is planned to integrate informatics in grades 10-12 by 2017 as a compulsory subject, depending on school curricula.
- Norway has started piloting the introduction of programming as an elective subject in 143 lower secondary schools, but has no certain plans for compulsory education.
- Likewise, in Sweden the government has recently requested the Swedish National Agency for Education to formulate suggestions for changing the national curricula, including the strengthening of the digital competence and programming.
- Ref: Bocconi, S., Chiocciariello, A., Dettori, G., Ferrari, A., Engelhardt, K. (2016). Developing computational thinking in compulsory education – Implications for policy and practice; EUR 28295 EN; doi:10.2791/792158  
<https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/developing-computational-thinking-compulsory-education-implications-policy-and-practice>
- <sup>5</sup> [https://www.idunn.no/dk/2014/03/look\\_to\\_denmark](https://www.idunn.no/dk/2014/03/look_to_denmark)
- <sup>6</sup> <https://iml.edusci.umu.se/conferences/files/2015/11/Program-Future-tests-and-test-environments.pdf> (PDF)
- <sup>7</sup> <http://plchelsinki.fi/visiting-researcher-skulina-hlif-kjartansdottir/>
- <sup>8</sup> <http://hultsfredsgymnasium.se/2016/09/invigning-makerspace-hultsfred/>
- <sup>9</sup> <http://www.hippomini.dk/projects>
- <sup>10</sup> <http://nordic.businessinsider.com/15-of-the-most-beautiful-schools-around-the-world-2016-10/>
- <sup>11</sup> <http://search.proquest.com/openview/41cd0556e613cfa4da02180e17d05220/1?pq-origsite=gscholar&cbl=1006500>
- <sup>12</sup> [http://yle.fi/uutiset/osasto/news/coding\\_soon\\_to\\_be\\_part\\_of\\_finnish\\_schoolchildrens\\_core\\_curriculum/7818567](http://yle.fi/uutiset/osasto/news/coding_soon_to_be_part_of_finnish_schoolchildrens_core_curriculum/7818567)
- <sup>13</sup> <http://www.powerhouse.no/en/aktuelt/norwegian-village-drobak-to-host-the-first-powerhouse-lower-secondary-school/>
- <sup>14</sup> <http://www.thelocal.se/20161206/what-swedens-improving-school-performance-tells-us-pisa>
- <sup>15</sup> <http://www.thelocal.se/20160928/sweden-climbs-global-competitiveness-ranking>
- <sup>16</sup> <http://prosjektsider.hsh.no/respmath/>
- <sup>17</sup> <https://nettsteder.regjeringen.no/fremtidensskole/mandate-in-english/>
- <sup>18</sup> <http://www.sciencedirect.com/science/article/pii/S0360131516300859>
- <sup>19</sup> [https://www.dge.mec.pt/sites/default/files/Noticias\\_Imagens/1\\_curriculum\\_in\\_finland.pdf](https://www.dge.mec.pt/sites/default/files/Noticias_Imagens/1_curriculum_in_finland.pdf) (PDF)
- <sup>20</sup> <http://www.elmmagazine.eu/articles/validation-of-non-formal-learning-moves-up-a-gear>
- <sup>21</sup> [http://www.arene.fi/sites/default/files/PDF/2016/FinPro-Ministry-screen-version\\_090216-v4-HQ.pdf](http://www.arene.fi/sites/default/files/PDF/2016/FinPro-Ministry-screen-version_090216-v4-HQ.pdf) (PDF)
- <sup>22</sup> <http://www.linkoping.se/contentassets/20233e733afd40c6ad914aa7ef383c2c/erasmus-2017-ka2-expression-of-interest-eng.pdf> (PDF)
- <sup>23</sup> <https://eskolermidtd.wordpress.com/about>
- <sup>24</sup> [http://www.uib.no/sites/w3.uib.no/files/rokenes\\_f.\\_m.\\_2016.\\_preparing\\_future\\_teachers\\_to\\_teach\\_with\\_ict\\_til\\_trykk\\_mai2016\\_0.pdf](http://www.uib.no/sites/w3.uib.no/files/rokenes_f._m._2016._preparing_future_teachers_to_teach_with_ict_til_trykk_mai2016_0.pdf) (PDF)
- <sup>25</sup> <https://www.oecd.org/sweden/promoting-well-being-and-inclusiveness-in-sweden.pdf> (PDF)
- <sup>26</sup> <http://www.digst.dk/ServiceMenu/English/Policy-and-Strategy/Digital-Strategy-2016to2020%20>
- <sup>27</sup> <http://www.minedu.fi/OPM/Tiedotteet/2016/11/peruskoulufloorumi.html?lang=en>
- <sup>28</sup> <http://www.oecd-ilibrary.org/docserver/download/9789264130852-sum-en.pdf?expires=1484343710&id=id&accname=guest&checksum=E07AA921419858A01497BF44A401A10E>
- <sup>29</sup> <http://www.cedefop.europa.eu/en/news-and-press/news/norway-digital-skills-education>
- <sup>30</sup> [http://www.o-ph.fi/english/current\\_issues/101/0/what\\_is\\_going\\_on\\_in\\_finland\\_curriculum\\_reform\\_2016](http://www.o-ph.fi/english/current_issues/101/0/what_is_going_on_in_finland_curriculum_reform_2016)
- <sup>31</sup> <http://www.ind.ku.dk/projekter/gymnasiettaentkforfra>
- <sup>32</sup> <https://digitaliseringskommissionen.se/wp-content/uploads/2014/06/Summary-report-ICT-schools-March-2014.pdf>
- <sup>33</sup> <http://www.cs.au.dk/~mec/publications/conference/41--ace2013.pdf> (PDF)
- <sup>34</sup> <http://searchmanufacturingerp.techtarget.com/definition/Rapid-prototyping>
- <sup>35</sup> <https://3dprint.com/57272/oslo-3d-printed-city-model/>
- <sup>36</sup> <http://www.wired.co.uk/article/3d-printing-production-line>
- <sup>37</sup> <http://www.mcvuk.com/news/read/territory-report-nordic-countries/0159530>
- <sup>38</sup> <https://www.diva-portal.org/smash/get/diva2:784874/FULLTEXT01.pdf> (PDF)
- <sup>39</sup> <http://www.ispringsolutions.com/blog/gamification-turning-e-learning-students-into-gamers/>
- <sup>40</sup> <https://techcrunch.com/2015/10/16/for-students-the-future-is-now/>
- <sup>41</sup> <http://www.ifla.org/node/9623>
- <sup>42</sup> <http://renovatedlearning.com/2015/04/02/defining-makerspaces-part-1/>
- <sup>43</sup> <http://www.builtinla.com/2016/06/30/groups-fixing-STEM-education-in-LA>

- 
- <sup>44</sup> <https://www.emarketer.com/Article/Smartphone-Ownership-Almost-Universal-Nordic-Countries/1013940>
- <sup>45</sup> <http://www.nordicstartupbits.com/2015/12/09/funzi-is-on-a-mission-to-figure-out-the-algorithm-for-learning/>
- <sup>46</sup> <http://tytonpartners.com/library/accelerating-adaptive-learning-in-higher-education/>
- <sup>47</sup> <http://www.laceproject.eu/blog/learning-analytics-in-the-norwegian-school-system/>
- <sup>48</sup> <http://www.computerworld.com/article/2906336/emerging-technology/what-is-artificial-intelligence.html>
- <sup>49</sup> <http://nordic.businessinsider.com/artificial-intelligence-could-double-the-economic-growth-of-finland-2016-10>
- <sup>50</sup> [http://www.sas.com/en\\_us/insights/analytics/machine-learning.html](http://www.sas.com/en_us/insights/analytics/machine-learning.html)
- <sup>51</sup> [http://artint.info/html/ArtInt\\_183.html](http://artint.info/html/ArtInt_183.html)
- <sup>52</sup> <http://www.finland.org/public/default.aspx?contentid=352706>
- <sup>53</sup> <http://www.nordicinnovation.org/news/heritage-hackers-hidden-won-hack4norden-2016/>
- <sup>54</sup> <http://phys.org/news/2015-05-robotic-technology-safety.html>
- <sup>55</sup> <https://hbr.org/2015/06/the-age-of-smart-safe-cheap-robots-is-already-here>
- <sup>56</sup> <http://fortune.com/2016/02/24/robotics-market-multi-billion-boom/>
- <sup>57</sup> <https://www.learntechlib.org/p/151372>
- <sup>58</sup> <http://www.blue-ocean-robotics.com/en/news/2016/april/press-release/pr2016-04-28-kubo>
- <sup>59</sup> <http://www.crowdfundinsider.com/2014/09/48879-speechtrans-surpassed-crowdfunding-goal-rockthepost-speech-speech-language-translation/>
- <sup>60</sup> <http://docplayer.me/1486801-Sakskart-til-mote-i-hovedutvalg-for-utdanning-og-kompetanse-10-03-2015.html>
- <sup>61</sup> <https://www.taus.net/think-tank/articles/translate-articles/speech-translation-technology-a-conversation-between-alexander-waibel-and-mark-seligman>
- <sup>62</sup> <http://blog.scientix.eu/2015/08/20/virtual-laboratories-in-teaching-and-learning-science/>
- <sup>63</sup> <http://cphftw.dk/portfolio-posts/labster/>
- <sup>64</sup> <http://www.business.dk/oekonomi/bedre-end-virkeligheden>
- <sup>65</sup> <http://www.aftenposten.no/norge/Dyp-laring-Slik-har-maskinene-begynt-a-lare-som-oss-60395b.html>
- <sup>66</sup> <http://www.mediapost.com/publications/article/283174/2-billion-consumers-projected-to-use-ai-powered-vi.html>
- <sup>67</sup> <http://www.businesswire.com/news/home/20160425005123/en/Nina-Virtual-Assistant-Nuance-Brings-Human-Touch>
- <sup>68</sup> <https://qz.com/797438/ipal-robot-entertains-children-without-adult-supervision/>
- <sup>69</sup> <http://www.edtechmagazine.com/k12/article/2016/03/virtual-reality-plus>
- <sup>70</sup> <http://tekniikanmaailma.fi/elektroniikka/10-kuumaa-teknologiatrendia-oikeasti-muuttavat-elamaa/>
- <sup>71</sup> <https://epsnews.com/2014/08/08/european-wearable-tech-market-grow-42-five-years/>
- <sup>72</sup> <http://quantifiedself.com/>
- <sup>73</sup> <http://www.edudemic.com/wearable-tech-mean-classroom/>

## The New Media Consortium

*Sparking innovation, learning and creativity*

1250 Capital of Texas Hwy South  
Building 3, Suite 400  
Austin, TX 78746

tel 512 445-4200  
fax 512 445-4205  
web [www.nmc.org](http://www.nmc.org)

ISBN 978-0-9977215-9-1