Technology Outlook
STEM+ Education 2012-2017

An NMC Horizon Report Sector Analysis

http://stem.wiki.nmc.org/

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1. **Introduction**

The *Technology Outlook: STEM+ Education 2012-2017* is part of a longitudinal research study of emerging technologies that began in March 2002. Since that time, under the banner of the Horizon Project, the NMC and its research partners have held an ongoing series of conversations and dialogs with its advisory boards — a group that now numbers nearly 500 technology professionals, campus technologists, faculty leaders from colleges and universities, museum professionals, teachers and other school professionals, and representatives of leading corporations from more than 30 countries. For more than a decade, these conversations have been mined to provide the insights on emerging technology that are published annually in the *NMC Horizon Report* series.

The STEM+ project is being conducted in collaboration with the Centro Superior para la Enseñanza Virtual (CSEV), the Departamento de Ingeniería Eléctrica, Electrónica y Control at the Universidad Nacional de Educación a Distancia (UNED), and the Institute of Electrical and Electronics Engineers Education Society (IEEE Educational Society).

The report was published in September 2012, and focused on emerging technology and its applications to STEM+ education. This is the first year of publication for this particular report. (For a similar example, see the Technology Outlook for Australian Tertiary Education 2012-2017).

The NMC Horizon Project is currently in its tenth year, dedicated to charting the landscape of emerging technologies for teaching, learning, and creative inquiry in education globally. In 2008, the NMC added to the three main *NMC Horizon Reports* a new series of regional and sector-based studies, called the *NMC Technology Outlooks*, with the dual goals of understanding how technology is being absorbed using a smaller lens, and also noting the contrasts between technology use in one area or field compared to another. To date, the NMC has conducted studies of technology uptake in Australia, New Zealand, the UK and Iberoamerican countries, and has plans in place to expand that research to Central Europe, India, Singapore, and Brazil. The flagship *NMC Horizon Report*, focused on higher education, is translated into multiple languages every year. Over all editions, the readership of the reports is estimated at over one million worldwide, with readers in over 100 countries.

This project, the *Technology Outlook: STEM+ Education 2012-2017*, is the first of its kind in the *Horizon Report* series. It focuses specifically on STEM+ education and the emerging technologies, key trends, and critical challenges that are impacting it. The members of the horizon.stem advisory board were purposely chosen to represent a broad spectrum in STEM+ education; key writers, thinkers, technologists, and futurists from education, business, and industry round out the group.

In this wiki, they will be engaging in a comprehensive review and analysis of research, articles, papers, blogs, and interviews; discussing existing applications, and brainstorming new ones; and ultimately ranking the items on the list of candidate technologies for their potential relevance to teaching, learning, or research in STEM+ education. The results of this ranking will be published in the *Technology Outlook: STEM+ Education 2012-2017.*

2. **Timeline**

Date	Activity
July 23, 2012	Advisory Board convened
July 23 - 26, 2012	Wiki Orientations for Advisory Board as needed
July 23 - August 5, 2012	Advisory Board reviews/adds to Press Clippings
August 6 - 19, 2012	**Advisory Board answers the Research Questions**
August 20 - 26, 2012	**Advisory Board makes its Rankings**
August 27 - September 9, 2012	NMC Staff produce the "Technology Outlook"
September 10, 2012	Review copy of published report sent to Advisory Board and VIP list in PDF format
September 21, 2012	2012 Horizon.STEM Report released in Madrid at UNED

3. *Methodology*

The process used to research and create the Technology Outlook for STEM Education in 2012-2017 is very much rooted in the methods used throughout the Horizon Project. All editions of the NMC Horizon Report 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 advisory board 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 technologies, trends, and challenges is selected.

This process takes place online, where it is captured and placed in the NMC Horizon Project wiki. The wiki 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 STEM Edition can be found at http://stem.wiki.nmc.org.

The procedure for selecting the topics in the report included a modified Delphi process now refined over years of producing the NMC Horizon Report series, and began with the assembly of the advisory board. The advisory board represents a wide range of backgrounds, nationalities, and interests, yet each member brings a particularly relevant expertise. Over the decade of the NMC Horizon Project research, more than 500 internationally recognized practitioners and experts have participated on project advisory boards; in any given year, a third of advisory board members are new, ensuring a flow of fresh perspectives each year. Nominations to serve on the advisory board are encouraged — see go.nmc.org/horizon-nominate.

Once the advisory board 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. Advisory board 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 in this edition is its potential relevance to teaching, learning, and research in STEM education. A carefully selected set of RSS feeds from hundreds of relevant publications ensures that background resources stay current as the project progresses. They are used to inform the thinking of the participants throughout the process.

Following the review of the literature, the advisory board engages in the central focus of the research — the research questions that are at the core of the NMC Horizon Project. These questions were designed to elicit a comprehensive listing of interesting technologies, challenges, and trends from the advisory board:
Which of the key technologies catalogued in the Horizon Project Listing will be most important to teaching, learning, or research in STEM education within the next five years?

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

What would you list among the established technologies that some educational institutions are using today that arguably ALL institutions should be using broadly to support or enhance STEM teaching, learning, or research?

What technologies that have a solid user base in consumer, entertainment, or other industries should educational institutions be actively looking for ways to apply?

What are the key emerging technologies you see developing to the point that STEM learning-focused institutions and programs should begin to take notice during the next four to five years?

What do you see as the key challenges related to teaching, learning, or research that STEM educational institutions and programs will face during the next five years?

What trends do you expect to have a significant impact on the ways in which STEM educational institutions and programs approach our core missions of teaching, learning, and research?

One of the advisory board'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 advisory board moves to a unique consensus-building process based on an iterative Delphi-based methodology.

In the first step of this approach, the responses to the research questions are systematically ranked and placed into adoption horizons by each advisory board 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.

From the comprehensive list of technologies originally considered for any report, the 12 that emerge at the top of the initial ranking process — four per adoption horizon — are further researched and expanded. Once this list is identified, the group, working with both NMC staff and practitioners in the field, begins to explore the ways in which these twelve important technologies might be used for teaching, learning, and research in STEM education. A significant amount of time is spent researching real and potential applications for each of the areas that would be of interest to practitioners.

For additional detail on the project methodology or to review the actual instrumentation, the ranking, and the interim products behind the report, please visit http://stem.wiki.nmc.org.

4. *Key topics*

3D Printing
3D Video
Alternative Licensing
Augmented Reality
Cloud Computing
Collaborative Environments
Collective Intelligence
Crowd Sourcing
Digital Identity
Digital Preservation
Electronic Publishing
Federated Experiments
Geolocation
Gamefication
Internet of Things
Learning Analytics
Location-Based Services
Massively Open Online Courses
Mobiles
Mobile Apps
Natural User Interfaces

New Scholarship
Next Generation Batteries
Open Badges
Open Content
Open Hardware
Personal Learning Environments
Remote Laboratories
Semantic Applications
Simulators
Social Media
Social Networking
Statistical Machine Translation
Tablet Computing
Telepresence
Video Lectures
Virtual Assistants
Virtual Laboratories
Virtual Worlds
Visual Data Analysis
Wireless Power

5. *Key trends*

The key trends found by the advisory board are:

- **The abundance of resources and relationships made easily accessible via the Internet is increasingly challenging us to revisit our roles as educators.** This multi-year trend from global report was again ranked very highly, indicating its continued influence, specifically in the UK. Institutions must consider the unique value that each adds to a world in which information is everywhere. In such a world, sense-making and the ability to assess the credibility of information are paramount. Mentoring and preparing [[#|students]] for the world in which they will live -- the central role of the university when it achieved its modern form in the 14th century -- is again at the forefront. (Carried forward from the 2011 Technology Outlook for UK Tertiary Education) Uriel.Cukierman Today 11:09 am

- **As Massive Open [[#|Online Courses]] are proliferating in STEM areas, the quality of free education is improving.** MOOCs such as MITx, Coursera, and the Code Academy have been launched by world-class institutions (including MIT and Stanford) as an alternative method to traditional in-class learning. Because of the heavyweights behind these initiatives, the quality of the online courses has been heightened, lending more credibility to MOOCs. - **Christian.Guetl** Aug 9, 2012 2:13 am might be relevant for both formal and informa / life-long enducation - **Christian.Guetl** Aug 9, 2012 2:44 am very relevant. The pedagogy of MOOCs seems to be split into two broad camps: connectivisit/constructivist (Downes, Siemens, Cormier, Groom) vs instructivist (EdX, Cousera, Udacity, Udemy, etc). The latter seem to be more in the STEM area … for now. - **Nick** Aug 14, 2012 6:58 pm- **Sam** Aug 17, 2012 7:43 am user/ Salvador.Ros user/ Zeinab.El.Maadawi

- **Computers as we know them are in the process of a massive reinvention.** The computer is smaller, lighter, and better connected than ever before, without the need for wires or bulky peripherals. In many cases, smart [[#|phones]] and other mobile devices are sufficient for basic computing needs, and only specialized tasks require a keyboard, large monitor, and a mouse. Mobiles are connected to an ecosystem of applications supported by cloud computing technologies that can be downloaded and used instantly, for pennies. As the capabilities and interfaces of small computing devices improve, our ideas about when -- or whether -- a traditional computer is necessary are changing as well. (Carried forward from the 2011 Technology Outlook for UK Tertiary Education). The availability of 'phablet' type technologies for convenience and flexibility to access courses. Future generations will be skilled to use all forms of social media and technologies and the development and design of courses may be used more readily using smart phones, tablets, etc. - **Vanessa.Chang** Aug 16, 2012 7:09 am

- **Education paradigms are shifting to include online learning, hybrid learning and collaborative models.** Budget cuts have forced institutions to re-evaluate their education strategies and find alternatives to the exclusive face-to-face learning models. Students already spend much of their free time on the Internet, learning and exchanging new information -- often via their social networks. Institutions that embrace face-to-face/online hybrid learning models have the potential to leverage the online skills learners have already developed independent of academia. We are beginning to see developments in online learning that offer different affordances than physical campuses, including opportunities for increased collaboration while equipping students with stronger digital skills. Hybrid models, when designed and implemented

successfully, enable students to travel to campus for some activities, while using the network for others, taking advantage of the best of both environments. (Carried forward from the NMC Horizon Report > 2012 HiEd Edition) - **Christian.Guetl** Aug 9, 2012 2:13 am I see this as one of the most important aspects,

Not only these, but also the inclusion (i.e., fostering and supporting) of informal learning and autonomous learning, and the bridging of all these forms of learning. The aim is to nurture a holistic and learner-centric learning culture which will eventually turn learners into life-long learners.- **Lung-Hsiang.Wong** Aug 18, 2012 2:54 am Modern teaching practices now make extensive use of video and other online digital content to "flip" the classroom. Students can review full lecture videos or clips of lecture topics, visualize classroom cases, reexamine lab practices, learn languages outside of class while dedicating time in class to focus on specific issues or doing exercises. But unlike in a live classroom, the delivery of online content via video for example induces passive learning. Because of its unidirectionality, video doesn't allow students to participate and collaborate with peers by enriching the discourse with their perspective or make inquiries about the material being delivered. Contextualized annotation tools in pedagogy introduce a new model of engagement with the online material transforming the discourse into a bidirectional exchange. By being able to add questions, add enriching commentaries or clarifying marginalia to segments of video or other digital content, the student becomes more engaged. Collated annotation data over a given time period offers the potential to review and examine changes in development of teaching practices. Through student commentaries teachers can assess the level of engagement with the digital material, by individuals or by the entire class. Teachers can also take note of specific topic areas where students are having difficulties to later address the issues in person or by embedding new reformulated material as commentaries within the video. Teachers can further reflect on their own teaching methods based on the feedback gathered though student commentaries or questions about the material. - **pdesenne** Aug 21, 2012 1:11 pm

- **Enhanced electronic books are increasingly being used instead of traditional textbooks.** As e-book technology advances, digital textbooks contain more dynamic content, including audio, videos, and other interactive features. Traditional textbooks are cumbersome and can take years to update and reprint when there is new information and discoveries to be added. However, e-books can be easily revised and disseminate as often as needed, and the cost to produce one is significantly less than that of a print book.

- **The federation of online experiments allows the creation of new markets where instituions can share, buy, and sell access online resources.** These experiments may be based in any variety of LMS, KMS, CMS or websites, and promote the creation of a single resource that can satiate the needs of many universities. The best federated online experiments are able to be easily integrated in a range of environments and allow single sign-on. – **Christian.Guetl** Aug 9, 2012 2:44 am

- **The growing availability of bandwidth will dramatically change user behaviours in teaching, learning and research over the next five years.** The advent of cloud computing has alleviated the burden of storing software, email services, and other applications locally. Major resources are now accessible via web browser in just one click, no longer bogging down computer speed. Students and educators can now connect and collaborate with more ease, transfer files and information quicker, and store more new content. (Carried forward from the 2011 Technology Outlook for UK Tertiary Education).

- **Increasingly, students want to use their own technology for learning.** As new technologies are developed at a more rapid and at a higher quality, there is a wide variety of different devices, gadgets, and tools from which to choose. Utilizing a specific device has become something very personal -- an extension of someone's personality and learning style -- for example, the iPhone vs. the Android. There is comfort in giving a presentation or performing research with tools that are more familiar and productive at the individual level. And, with handheld technology becoming mass produced and more affordable, students are more likely to have access to more advanced equipment in their personal lives than at school. (Carried forward from the 2011 Technology Outlook for UK Tertiary Education)- **Christian.Guetl** Aug 9, 2012 2:13 am this is for me very relevant and important as well

- **Institutions are increasingly exploring technologies that allow teachers and students to better collaborate. Social networks and** cloud-based tools and applications are changing the ways teachers and students communicate with each other. Open resources such as wikis and Google Apps also enable the free exchange of ideas and prompt insightful discussions between teachers and students. The result is more opportunities for collaboration, and a change in the dynamic of the teacher-student relationship that promotes more of an equilibrium. (Carried forward from the NMC Horizon Project > 2012 HiEd Short List)

- **Lecture capture, podcasting, and cheap personal video recorders increasingly make it much easier to prepare lecture-style content for students to see/hear before coming to class.** There is an ever-growing cadre of professors posting lectures, pre-lectures, and other video-based reflections online. Similar to how students would prepare for class by reading a book, they can now watch or listen to educators exploring the course material beforehand. This frees up time during class to engage in responsive activities and collaborative problem-solving. The driving forces behind this trend are popular models such as Khan Academy, which contains thousands of brief video tutorials that convey material. (Carried forward from the NMC Horizon Project > 2012 HiEd Short List)

- **Pedagogical approaches that have long been identified as valuable and promising, but were not feasible due to time or cost constraints, are now possible thanks to the evolution of technology.** In many ways, emerging technologies enable the facilitation of new pedagogies. Teachers are now able to leverage new tools to apply their creativity to different learning activities. Tablet computing, for example, allows students to engage in more challenge- and project-based learning, as they can now explore and collect data from various environments on-the-go outside of the classroom. The technology also makes it easier for educators to devise and test new pedagogies before implementing them. - **Christian.Guetl** Aug 9, 2012 2:44 am

- **People expect to be able to work, learn, and study whenever and wherever they want to.** This trend, noted in several recent NMC Horizon Reports, continues to permeate all aspects of daily living. Life in an increasingly busy world where learners must balance demands from home, work, school, and family poses a host of logistical challenges with which today's ever more mobile students must cope. A faster approach is often perceived as a better approach, and as such people want easy and timely access not only to the information on the network, but to their social networks that can help them to interpret it and maximize its value. The implications for informal learning are profound, as are the notions of just-in-time learning and found learning, both ways of maximizing the impact of learning by ensuring it is timely and efficient. (Carried forward from the NMC Horizon Report > 2012 HiEd Edition) - **Christian.Guetl** Aug 9, 2012 2:44 am- **Holly.Lu** Aug 25, 2012 6:48 pm we are definitely becoming a learn anytime, anywhere society.

- **Recognition and acceptance by tertiary educators of the potential of new technologies is increasing.** On many levels, what used to be considered emerging tools and new teaching and learning approaches have now reached mainstream adoption among educators. Maximizing online opportunities is one of the most notably accepted concepts. More than ever, teachers and administrators are embracing new technologies because there is now so much well-documented research on the positive outcomes they generate. Collaborations between other educational institutions have yielded lists of best practices and other tangibles that prove the worth of technology in learning. Communities and networks of practice are supporting educators as they experiment with new ideas and share their results. (Carried forward from the 2011 Technology Outlook for New Zealand Tertiary Education)- **Christian.Guetl** Aug 9, 2012 2:44 am fully agree

- **STEM courses and subjects are being gamified to bolster student engagement.** Institutions and individual educators are using badges, levels, karma points, and role-playing to provoke deeper interest from students in STEM learning. In many cases, this is proving to be more successful and cost-effective than developing and incorporating video games.

- **Students are engaging in more STEM practice activities online.** Virtual and remote labs are becoming increasingly valuable as high quality laboratory web applications and remote professional equipments are enabling students to perform experiments as many times as they like from wherever they are. These online labs are being further enhanced by learning objects, or a collection of content, practice, and assessment items that help the student achieve a particular learning objective.

- **The technologies we use are increasingly cloud-based, and our notions of IT support are decentralized.** The continuing acceptance and adoption of cloud-based applications and services is changing not only the ways we configure and use software and file storage, but even how we conceptualize those functions. It does not matter where our work is stored; what matters is that our information is accessible no matter where we are or what device we choose to use. Globally, in huge numbers, we are growing used to a model of browser-based software that is device-independent. While some challenges still remain, specifically with notions of privacy and control, the promise of significant cost savings is an important driver in the search for solutions. (Carried forward from the 2011 Technology Outlook for UK Tertiary Education) -

Christian.Guetl Aug 9, 2012 2:13 am I think the fact having device indepentency is more important than emphazising the buzz world cloud-based; it will be an institutions decission where and how they organize applications, content and data

- **There is a new emphasis in the classroom on more challenge-based and active learning.** Challenge-based learning and similar methods foster more active learning experiences, both inside and outside the classroom. As technologies such as tablets and smartphones now have proven applications in higher education institutions, educators are leveraging these tools, which students already use, to connect the curriculum with real life issues. The active learning approaches are decidedly more student-centered, allowing them to take control of how they engage with a subject and to brainstorm and implement solutions to pressing local and global problems. The hope is that if learners can connect the course material with their own lives, their surrounding communities, and the world as a whole, then they will become more excited to learn and immerse themselves in the subject matter. (Carried forward from the NMC Horizon Report > 2012 HiEd Edition) -
Christian.Guetl Aug 9, 2012 2:44 am Couldn't agree more that students must relate themselves to 'Learning' and learning must be applicable and valuable to students. Learning must be connected with the industry that the students are progressing towards their profession. Learning must incorporate international perspectives and learning must also include intercultural and ethic perspectives- **Vanessa.Chang** Aug 16, 2012 6:57 am. CBL resonates beautifully with STEM -
 http://www.nmc.org/projects/challenge-based-learning - this framework brings the best of PBL and inquiry based learning to the next level involving the community in a global context - the implications for STEM+ are boundless if challenges focus around STEM issues. [[user:Holly.Lu|1345945713]

- **What were previously thought of as new and disruptive forms of scholarship are now becoming the norm for scholarly communication.** Blogs, open textbooks, electronic journals, and forms of expression embodied in new media formats have challenged notions of scholarly writing and communication for several years. Yet these techniques are increasingly common and are readily accepted as informal outlets for scholarly work. A more gradual trend toward official acceptance is moving slowly, but its stirrings are visible in the adoption of electronic content, experiments with crowd-sourcing, and open, online peer review of scholarly work. This trend is related to the challenge of developing metrics for evaluating such work, noted in the 2010 Horizon

Report, as well as again in 2011. (Carried forward from the 2011 Technology Outlook for UK Tertiary Education)

- **The world of work is increasingly collaborative, driving changes in the way student projects are structured.**As more and more employers are valuing collaboration as a critical skill, silos both in the workplace and at school are being abandoned in favour of collective intelligence. To facilitate more teamwork and group communication, projects rely on tools like wikis, Google Doc, Skype, and online forums. Projects are increasingly evaluated by educators not just on the overall outcome, but also on the success of the group dynamic. In many cases, the online collaboration tool itself is an equally important outcome as it stores -- and even immortalizes -- the process and multiple perspectives that led to the end results. (Carried forward from the 2011 Technology Outlook for UK Tertiary Education).

- **Organizational forms of education - in particular on tertiary level - will change.** Students will are about to compile lectures from differnt universities / online corses according thier interests. globalized learning and collaboration over boarders and continents will raise significatly. open lectures such as from MIT will increase this situation. new forms of assessment and certificates are requested.- **Christian.Guetl** Aug 9, 2012 2:13 am Is this happening? How is APL and credentialing being handled?- **Nick** Aug 14, 2012 7:01 pm

- **Micro-credits and the proliferation of short course modules are leading to new forms of certifying learning.** This is actually a derivative outcome of the badging movement and MOOCs. As learning modules are developed with demonstrable outcomes, following the develop of badge technologies and approaches the certifications that are given to the student upon completion of these learning activities open up the question of how they will be aggregated and assessed in comparison to more traditional semester-based offerings by traditional university programs. This opens the door for a third-party (or parties - plural) to provide new validation services and a credit metric that industry and business may well honour given the direct evidence of the learning claimed. Once the monopoly around certification is questioned, the university lock on that market begins to crack and a new learning order has the potential to rise. MOOCs, badges and the increasing demand for relevant and authentic CPD have the potential to drive this toward a tipping point. - Phillip.Long - Zeinab.El.Maadawi

- **Educational Games - for play and as student game creators - are increasingly being used to not only master STEM concepts, but also apply and assess them.** Examples: BrainPOP GameUp wwww.brainpop.com/games/ and stemchallenge.org - kari.stubbs

- **As schools and districts struggle with how to develop instructional materials related to common core, broad stroke changes are coming in how teachers approach STEM instruction.**Common Core - I think that there will be significant implications due to changes with standards. Common core for example asks students to not only regurgitate information, but also demonstrate understanding through application. - kari.stubbs

- **Increasingly tagging is being standardized so that it can be more easily shared and located across space boundaries.** - kari.stubbs

- **Social media is changing the way people interact with each other, present information to each other, and judge the quality of contributions made by others** (the like / dislike paradigm that has startled so many researchers). Free social media tools have the ability to disseminate academic content to not only current students, but also alumni and the general public. Social media is changing how institutions recruit and retain students also. - Russ.Meier

- **Interoperability, integration and standarization**. If it is not a current trend should be a chall enge. - Salvador.Ros

- **Partnerships are changing the way we do business**. Rethinking the Way in Which Educational Institutions harness partnerships . Whether it's between schools, between states, with business and district....One example is how BrainPOP has reached out to best of breed game developers like Filament Games, iCivics.org, NCTM, eLine Media and more to bring educational games to teachers and kids for FREE. - kari.stubbs Today 6:57 am Agree - Zeinab.El.Maadawi Today 8:53 am

- **Economic Conditions are causing schools and districts to get leaner and meaner.** This has impacted a whole host of education issues, including the above mentioned partnerships, BYOD as an economic solution, the types of resources that schools can afford, etc. - kari.stubbs Today 6:57 am Agree & according to economies of scale, mobile devices are going to be cheaper & more available even for students in developing countries. - Zeinab.El.Maadawi Today 8:55 am the BYOD movement, due to this economic change, means administrators and educators need to rethink when and where learning takes place - **Holly.Lu** Aug 25, 2012 6:48 pm

- **New pedagogical models will be mainly focused, not in the technology itself, but in the way we use that technology in order to facilitate new models of education to be developed and implemented.** Another key factor will be how to avoid that technology widens the digital gap, specially the gap that still exists between digital natives and digital immigrants. - Uriel.Cukierman Today 11:09 am

- **The tools for creating technology itself are being put in students' hands.** Coding for all: In building on the point above, I think there can be a distinction in the new focus on providing the knowledge and tools for new coders to program their own tools. From OLPC's early focus on providing an activity that would teach child users basic program commands to the recent announcement of the Khan Academy [http://www.khanacademy.org/cs] announcing a big push to teach computer science, the tools for creating technology itself are being put in students' hands. - **jennifer.deboer** Aug 18, 2012 9:04 pm I might perhaps add to this the maker movement. - **jennifer.deboer** Aug 18, 2012 9:06 pm -- Cant agree more, but not only at child level. Programming is a great strategy to analyze problems and synthesize solutions. Which means understanding! App development can be a fun way to study some physical process and produce a model, perhaps running in a mobile- **antonio.vantaggiato** Aug 18, 2012 10:20 pm *[Editor: Moved here from RQ2.]*

- **Labeling what we do as teachers - Tech vs. STEM vs. General Education, etc. has become a trend.** We're coming out of a period where we tended to segment ourselves as educators and the professional organizations that supported us fell into those similar buckets. For example, when technology resources first appeared in the classroom, there was a push to network with likeminded trailblazers related to the use of technology to teach. We went to technology related conferences, joined technology focused discussion forums, etc. Recently

and moving forward, I expect the conversation to shift back to a broader view of general education. How do these evershifting tools help us engage, inspire, and teach our children. The conversation will shift back to best practices, attaching a megaphone to those best practices, and technology will increasingly been seen as the tool rather than the anchor for those discussions. - kari.stubbs *[Editor: Moved here from Challenges section]*

6. *Key challenges*

The key challenges defined by the advisory board are:

• **Appropriate metrics of evaluation lag the emergence of new scholarly forms of authoring, publishing, and researching.** Traditional approaches to scholarly evaluation such as citation-based metrics, for example, are often hard to apply to research that is disseminated or conducted via social media. New forms of peer review and approval, such as reader ratings, inclusion in and mention by influential blogs, tagging, incoming links, and re-tweeting, are arising from the natural actions of the global community of educators, with increasingly relevant and interesting results. These forms of scholarly corroboration are not yet well understood by mainstream faculty and academic decision makers, creating a gap between what is possible and what is acceptable. (Carried forward from the 2011 Technology Outlook for UK Tertiary Education)

• **Augmented reality applications are not yet available to every teacher.** Currently, not enough affordable and user-friendly augmented reality authoring tools are provided to educators, which is preventing AR from approaching mainstream adoption. - **Christian.Guetl** Aug 9, 2012 2:40 am fully agree

• **Commercial providers are delivering ever more credible educational content, providing a wide range of customizable offerings at quality levels that may dampen interest in traditional sources of scholarly work, such as university presses, and even open educational resources (OERs).** Increasingly, publishers are either buying learning resource websites or creating their own virtual warehouses of digital textbooks and other educational content. iTunes University is a prime example of this, offering thousands of course materials for free from distinguished institutions and professors. This trend creates a related challenge for university presses that have traditionally been the publishers of much of the work of their faculties; there is a growing fear that they will become obsolete. Both OERs and university presses are at a critical juncture for different reasons, yet each is aggressively confronted with the need to adapt, evolve, or even reconstruct their roles in education over the next five years. (Carried forward from the 2011 Technology Outlook for UK Tertiary Education).

• **Cross-institution authentication and detailed access policies are needed to allow sharing of online experiments among institutions.** While teachers are more equipped than ever to produce online experiments, what they are creating is often not effective or scalable. There is currently not enough documentation on quality standards of online experiments to adhere to, and many institutions are being repetitive, creating the same types of experiments that could be otherwise shared across many universities. - **Christian.Guetl** Aug 9, 2012 2:40 am very important- **Sam** Aug 17, 2012 7:44 am Institutions need to look at open standards for exchanging authentication and authorization to access data and tools between institutional security domains. Federated single sign-on (SSO) XML-based protocols such as Security Assertion Markup Language 2.0 (SAML 2.0) are critical to the success of sharing online experiments through commonly accessed tools. - **pdesenne** Aug 21, 2012 1:51 pm

• **The demand for personalized learning is not adequately supported by current technology or practices.** The increasing demand for education that is customized to each student's unique needs is driving the development of new technologies that provide more learner choice and control and allow for differentiated instruction. It has become clear that one-size-fits-all teaching methods are neither effective nor acceptable for today's diverse students. Technology can and should support individual choices about access to materials and expertise, amount and type of educational content, and methods of teaching.

(Carried forward from the NMC Horizon Project > 2012 HiEd Short List)- **Christian.Guetl** Aug 9, 2012 2:40 am

- **The development of remote laboratories is challenging for teachers.** Those teachers who know how to create the interface to the lab hardware generally are not equipped with the skills to create an effective web infrastructure, which is the crucial step that makes the remote lab public, or available to a specific group of students. - **Christian.Guetl** Aug 9, 2012 2:40 am standard experiments and most common subjects could be easily shared by institutions; I do not see that this is a major problem rather than organizing lerning experineces around the experiment

- **Digital media literacy continues its rise in importance as a key skill in every discipline and profession.** This challenge, driven by a related trend, appears here because despite the widespread agreement on the importance of digital media literacy, training in the supporting skills and techniques is rare in teacher education and non-existent in the preparation of faculty members. As lecturers and professors begin to realize that they are limiting their students by not helping them to develop and use digital media literacy skills across the curriculum, the lack of formal training is being offset through professional development or informal learning, but we are far from seeing digital media literacy as a norm. This challenge is exacerbated by the fact that digital literacy is less about tools and more about thinking, and thus skills and standards based on tools and platforms have proven to be somewhat ephemeral. (Carried forward from the 2011 Technology Outlook for UK Tertiary Education)- **Christian.Guetl** Aug 9, 2012 2:40 am

- **Dividing learning into fixed units such as credit hours limits innovation across the board.** For a long time now, credit hours have been the primary way of marking the progress of students in earning their college degrees. This method implies that time is an accurate and effective measure for knowledge comprehension and skill. This industrial construct hinders the growth of more authentic learning approaches, where students and teachers might make use of more creative strategies not bound by such constraints. (Carried forward from the NMC Horizon Project > 2012 HiEd Short List)- **Christian.Guetl** Aug 9, 2012 2:40 am fully agree - **Holly.Lu** Aug 25, 2012 6:59 pm yes, absolutely!

- **Economic pressures and new models of education are bringing unprecedented competition to the traditional models of tertiary education.** Across the board, institutions are looking for ways to control costs while still providing a high quality of service. Institutions are challenged by the need to support a steady — or growing — number of students with fewer resources and staff than before. As a result, creative institutions are developing new models to serve students, such as streaming introductory courses over the network. As these pressures continue, other models may emerge that diverge from traditional ones. Simply capitalizing on new technology, however, is not enough; the new models must use these tools and services to engage students on a deeper level. (Carried forward from the 2011 Technology Outlook for UK Tertiary Education).

- **The global drive to increase the number of students participating in undergraduate education is placing pressure across the system.** The off-cited relationship between earning potential and educational attainment, plus the clear impact of an educated society on the growth of the middle class is pushing many countries to encourage more and more students to enter universities and colleges. In many countries, however, the population of students prepared for undergraduate study is already enrolled — expanding access means extending it to students who may not have the academic background to be successful without additional support. Many in universities feel that these institutions do not have sufficient time and resources to help this set of students. (Carried forward from the NMC Horizon Project > 2012 HiEd Short List)

- **The growing choice that emerging technologies make possible — and how people navigate through this choice — is an on-going challenge.** When there are so many options for both educators and students on which technologies to use, it is easy to lose sight of how they will impact the teaching and learning process. In online learning environments in particular, there are a plethora of available communication, collaboration, and information management platforms. Individually, each tool or application may be effective, but when used all together, they can create a complex user interface where the focus is on the technologies rather than the learning. Navigating through the potential technologies and understanding how they will interact with each other to create a simple, easy-to-use environment is a pressing issue that must be solved at the conceptual — not implementation — level. (Carried forward

from the 2011 Technology Outlook for New Zealand Tertiary Education)- **Christian.Guetl** Aug 9, 2012 2:40 am

• **Institutional barriers present formidable challenges to moving forward in a constructive way with emerging technologies.** Too often it is education's own processes and practices that limit broader uptake of new technologies. Much resistance to change is simply comfort with the status quo, but in other cases, such as in promotion and tenure reviews, experimentation with or adoptions of clearly innovative applications of technologies is often seen as outside the role of researcher or scientist. (Carried forward from the NMC Horizon Report > 2012 HiEd Edition)

• **Most academics aren't using new and compelling technologies for learning and teaching, nor for organizing their own research - TPACK conceptualisation.** Many researchers have not undergone training on basic digitally supported teaching techniques, and most do not participate in professional development opportunities. This issue is due to several factors, including a lack of time, a lack of expectations that they should, and the lack of infrastructure to support the training. Academic research facilities rarely have the proper processes set up to accommodate this sort of professional development; many think a cultural shift will be required before we see widespread use of more innovative organizational technology. Many caution that as this unfolds, the focus should not be on the technologies themselves, but on the pedagogies that make them useful. (Carried forward from the 2011 Technology

Outlook for UK Tertiary Education) - **Christian.Guetl** Aug 9, 2012 2:40 am Faculty who have seen positive shifts in student engagement and achievement tend to be the ones who have taken the time to revisit the Scholarship of Teaching and explored how great teaching combined with the right technology can create new and more powerful learning experiences; the two variables interact so strongly that considering only one at a time (teaching or technology) does not result in the maximum effect (my

general summary of 9 years of edtech grantmaking - **jim.vanides** Aug 17, 2012 11:58 am)

• **New modes of scholarship are presenting significant challenges to libraries and university collections, how scholarship is documented, and the business models to support these activities.** While the university library has traditionally housed collections of scholarly resources, social networks and new publishing paradigms, including open content initiatives, are challenging the library's role as curator. Students and educators are increasingly able to access important, historic research in web browsers on devices of their choosing. As such, libraries are under tremendous pressure to evolve new ways of supporting and curating scholarship. (Carried forward from the 2011 Technology Outlook for UK Tertiary Education)

• **Online educational resources must be mobile-friendly.** Today's students want to be able to learn from wherever they are with whatever device they prefer. As smartphones and tablets gain more traction in educational settings, there is a demand for online content to keep up and load fast, look high quality,

and be easy to use across the growing array of mobile devices. - **Christian.Guetl** Aug 9, 2012 2:40 am agree, however mobile and conventional PC will blure more and more, and the problem will become minor.

The adoption of responsive design practices will completely bridge the mobile-pc content delivery divide and will allow users across multiple devices to have access to a single source of content. This will simplify and streamline the development and delivery process of new pedagogical content.-

pdesenne Aug 21, 2012 2:05 pm this is definitely important in the STEM future.- **Holly.Lu** Aug 25, 2012 6:59 pm

• **Organizations are challenged to ensure quality while engaging in the use of rapidly changing, ever-evolving technologies.** As new information and new technologies are readily available, at the fingertips of learners, educational institutions must find ways to intervene and remain a part of the relationship between the technology and the student. These organisations must make wise, up-to-date decisions when investing in and implementing technologies. To do so, they must conduct extensive research and regard technologies and their potential applications from all angles. Collaborations between institutions in the exploration of emerging technology provide them with opportunities to exchange ideas, success stories, obstacles, and develop best practices. (Carried forward from the 2011 Technology Outlook for New Zealand Tertiary Education)

• **Resource and service interoperability is key, but most of current developments do not include it.** The ability for various programs, devices, and systems to work together is important for an educational resource to be shareable and easy to integrate into different educational platforms and environments.

Unfortunately, checking for and understanding a resource's interoperability is a skipped that is often skipped in the development process at universities.

Adopting open standards in the development of pedagogical tools is the path to interoperability (open standards are interoperable by design). Universities must focus on syntactic and semantic interoperability which are key to the process. Syntactic interoperability is were more than one framework or system is capable of exchanging data and semantic interoperability is not just connecting and exchanging plain data but also attaching a meaning to the transmitted data and allowing machine to machine interpretation of the semantic strucures. Semantic interoperability relies on predetermined ontologies and one of the limitations in adopting semantic web standards in STEM is to agree on the use of common vocabularies

associated with their corresponding ontologies. - **pdesenne** Aug 21, 2012 1:40 pm

• **The role of the tertiary educator is changing.** As the focus in tertiary education shifts from teacher-centred, lecture-based classrooms to open educational resources (OERs), educators must adapt to the role of online facilitator. Because these OERs are loaded with pre-developed materials, teachers must sift through the resources and identify what is credible and revise the materials often as new information arises. In this sense, they will be online resource managers, but they also must develop creative ways to digitally interact with students in regards to those resources — otherwise they risk becoming dispensers of course materials rather than scholarly guides and instructional designers. (Carried forward from the

2011 Technology Outlook for New Zealand Tertiary Education) - **Christian.Guetl** Aug 9, 2012 2:40 am There is now a revolutionary change to education. Students learn differently with a short span of attention, flicking from screens to screens, swiping on phablets, texting approx. 300 sms a day - these students need to be engaged, motivated and enticed to learn from an exciting pool of resources. There are competing demands and the challenge for educators is to meet the need of these students. Professors are good at what they do, they profess, research, teach and are experts in their discipline areas but they are not usually skilled in the instructional design aspects of a course. Investment in extra resources is required

to empower professors to do their job effectively which is to profess, research and teach.- **Vanessa.Chang** Aug 16, 2012 7:27 am

• **Simply staying organized and current presents a challenge in a world where information, software tools, and devices proliferate at the rate they do today.** New developments in technology are exciting and their potential for improving quality of life is enticing, but it can be overwhelming to attempt to keep up with even a few of the many new tools that are released. User-created content is exploding, giving rise to information, ideas, and opinions on all sorts of interesting topics, but following even some of the hundreds of available authorities means sifting through a mountain of information on a weekly or daily basis. There is a greater need than ever for effective tools and filters for finding, interpreting, organizing, and retrieving the data that is important to us. (Carried forward from the NMC Horizon Project > 2012 HiEd Short List.)

• **Some emerging technologies are not mature enough to be applied to mainstream STEM education.** While universities are experimenting with various technologies, many of these technologies, such as robotics, are only in the development and research stages. It is risky to implement a new technology without standard implementation guidelines and sufficient research to back it up.

• **Education Credentialing is being examined from every angle, and is certain to change over the coming years.** This may take more than 5 years to hit but discussions may start sooner that we expect. All the changes going on with different forms of educational provision (open/closed, free/paid) and escalating costs may well lead to questions about ownership/authority for education credentialing. When this current generation of college and university students hits middle management and become responsible for hiring,

they may not necessarily stick with 'the credentialing system they experienced'- **Nick** Aug 5, 2012 7:58 pm

• **Institutional complacency is a challenge.** For many universities, the challenges ahead are just too hard. Either they see themselves as simply having ongoing relevance because in the past they have, or the recognise change is needed but they are unable to achieve any meaningful consensus around what they need to change. Either way, they're likely to fade into irrelevance or founder altogether, whether they become conscious of their fate or not. Like most technological changes, their primary impact is to disaggregate systems that were once seen as coherent wholes. Once the components can be treated separately, the integrity of the entity that was the proponent of the prior system weakens. Publishing, manufacturing, software development, all have faced and lived through this fate. Higher education's time is soon to come. - Phillip.Long

- **Labeling what we do as teachers - Tech vs. STEM vs. General Education, etc. has become a trend.** We're coming out of a period where we tended to segment ourselves as educators and the professional organizations that supported us fell into those similar buckets. For example, when technology resources first appeared in the classroom, there was a push to network with likeminded trailblazers related to the use of technology to teach. We went to technology related conferences, joined technology focused discussion forums, etc. Recently and moving forward, I expect the conversation to shift back to a broader view of general education. How do these evershifting tools help us engage, inspire, and teach our children. The conversation will shift back to best practices, attaching a megaphone to those best practices, and technology will increasingly been seen as the tool rather than the anchor for those discussions. - kari.stubbs *[Editor: Moved to Trends section of this wiki]*

- **As the tools that we use to engage students increasingly become personalized and thus varied, we'll run into a different "flavor" of the digital divide.** Previously much of the digital divide conversation was around differences and limitations in what some districts could provide their students. Now the discussion will have deeper roots in family and community. There is potential for a much broader range in device capability moving forward as those devices shift, as the US economy struggles to "get back on track" and as we look more globally at access. - kari.stubbs Agree & the same concept is applied globally - Zeinab.El.Maadawi Today 9:01 am We need to consider the particular situation in emerging economies - Uriel.Cukierman Today 11:16 am

- **Many published studies on the uses of new technologies in education do not address the pedagogical model used with the technology.** In other words, learning models are not fully considered when instructors adopt a technology. Just throwing some new technology into the mix doesn't mean the student learns better! Instead, the cognitive psychology of learning must be considered and technology integrated into the learning loop in appropriate ways. This area must become more of a collaborative focus for researchers in education and technology. - Russ.Meier -Zeinab.El.Maadawi Today 6:20 am - Salvador.Ros Today 5:06 am - Uriel.Cukierman Today 11:16 am

- **If we are going to use technology we need to ensure the assessment processes.** Ensure assessment process . who is making an exam or a practice?. - Salvador.Ros Today 5:06 am

- **Districts struggle to maintain a balance between providing each teacher with the exact same set of resources and also honoring those individual teachers who are willing to take risks and develop new approaches around new tools.** This poses a challenge. The district who chooses to provide the exact same set of equipment, guidelines, and trainings to each teacher in the district may risk missing the opportunity or the budget to support powerful pockets of innovation related to STEM instruction. Standardization of resources or a Push to support pockets of educational innovation. - kari.stubbs

- **As new advances in technology move opportunities in education further, it is vital that we consider questions of inequity and inequality.** The tools that are supposed to provide more open access are more easily accessed and navigated by those who are already privileged with some set of resources. In many cases, we see that digital divides widen rather than narrow with technology interventions. - **jennifer.deboer** Aug 20, 2012 1:38 pm

- **There is evidence that students in school face problems in understanding and applying math concepts.** ICT-based approaches can support to learn and train math competences as well as can help to apply it in different context. support should include symbolicas well as numeric support. some advanced systems already can assess students calculation, even stepwise and provide feedback and support. - user/ Christian.Guetl *[Editor's note: Moved here from RQ2.]*

- **Simply bringing more students into the STEM+ world, increasing the number of college graduates in STEM fields, especially females**. Right now we are having a hard time keeping current students in STEM college departments, and getting students interested in the field prior to college. There is a push in the lower/middle grades to grow the number of females in advanced science and math classes.- **Holly.Lu** Aug 25, 2012 6:57 pm
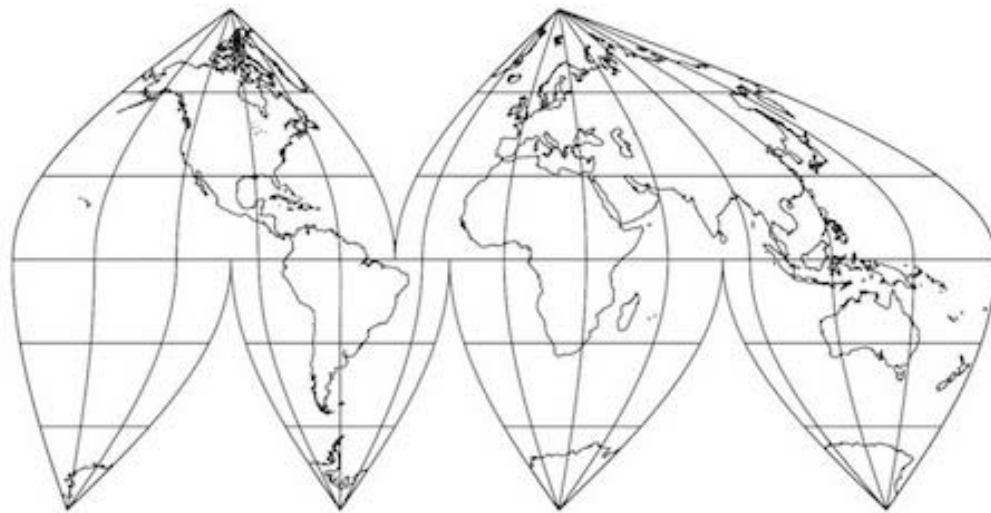
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An NMC Horizon Report Sector Analysis

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