Education and the Internet of Everything

How Ubiquitous Connectedness Can Help Transform Pedagogy

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Technology is just one of many disruptive influences in education today. We live in an era where the wealth of data and the exponential growth in the development of new knowledge is challenging institutions to rethink teaching and learning in a global market. There is also a need to prepare students for increasing competition in the workplace. With technology as a catalyst, education is moving from a knowledge-transfer model to a collaborative, active, self-directed, and engaging model that helps students increase their knowledge and develop the skills needed to succeed in the "Learning Society."[1]

Research shows that students learn by being actively engaged in relevant and authentic activities—and technology makes this increasingly possible. Learners are also becoming more adept at using social networks such as YouTube and Facebook to text message; post videos, blogs, and images; and collaborate and socialize regardless of time or place.

Furthermore, students are using software applications to either create or interact with content—even content that previously was only broadcast. More and more, classrooms are becoming "open" through voice, video, and text-based collaboration, and teachers now have a wide range of multimodal resources at their disposal to enhance teaching.

Alongside a growing understanding of how the brain works and how learning takes place, integrated technology solutions such as multimedia, games, and animation have played a significant role in improving time to mastery and understanding.

As more people adopt new technologies for learning, they will thrive in the emerging world of the Internet of Everything (IoE)—the networked connection of people, process, data, and things—which is becoming the basis for the Internet of Learning Things.[2]

This white paper discusses the potential of IoE and the challenges it presents to formal education, including:

- The impact connecting the unconnected has on learning
- How improvements in infrastructure/device availability have made 24/7 connectivity a reality in the developed world, and how emerging economies can benefit
- How cloud computing, augmented reality, Bring Your Own Device (BYOD), wearable technologies, and Big Data integrate with IoE
- How to get the most value from connecting people, processes, data, and things
- The knowledge educators must possess to exploit IoE and benefit learners
- Considerations for seizing the potential of IoE in education
- Risks and potential downsides of IoE
- How educators can influence policy makers to help shape IoE and maximize its gains in education

What is The Internet of Everything?

Cisco believes that many organizations are already experiencing the Internet of Things (IoT)—the networked connection of physical objects. The Internet of Everything is the next step in the evolution of smart objects—interconnected things in which the line between the physical object and digital information about that object is blurred.[3] IoT focuses only on sensor networks—machines communicating with other machines, and the data created as a result. As things add capabilities (such as context-awareness, increased processing power, and energy independence), and as more people and new information are connected, IoT becomes IoE (see Figure 1), a network of networks where billions, or even trillions, of connections create unprecedented opportunities and new risks.[4]

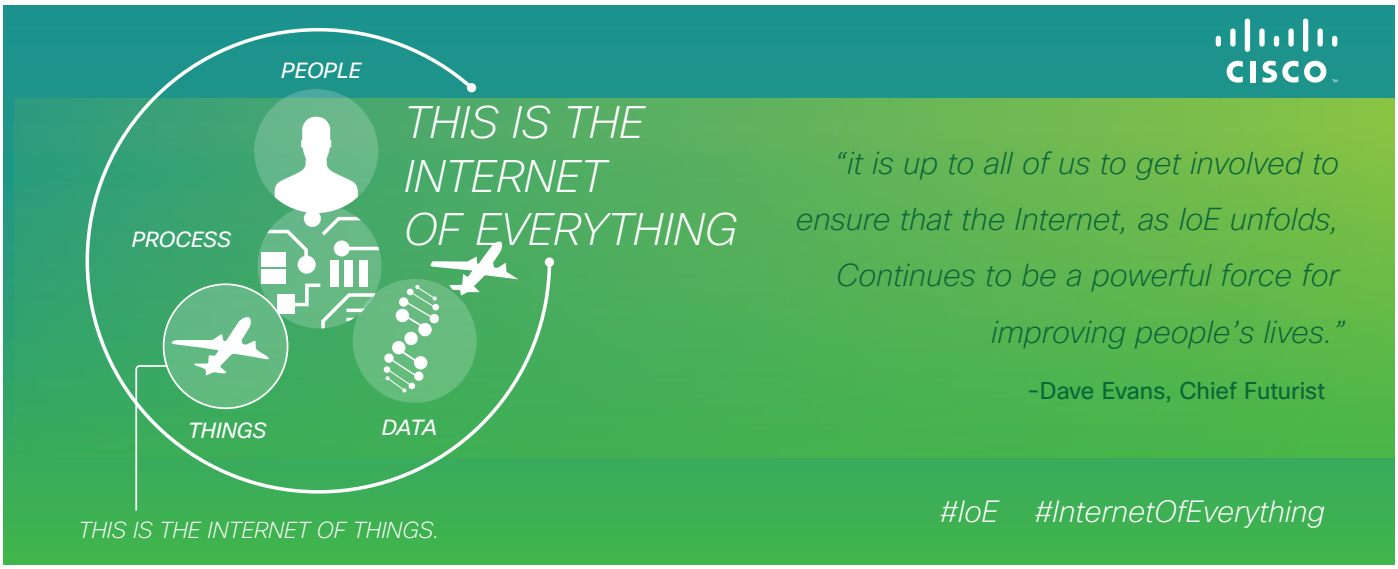
1 "The Learning Society," Cisco, 2010, http://bit.ly/a1YSqY.

2 Internet of Learning-Things," Edutech Associates, August 2013, http://bit.ly/1g3wPGP.

3 That 'Internet of Things' Thing: In the Real World, Things Matter More than Ideas," Kevin Ashton, July 2009, http://www.rfidjournal.com/articles/view?4986.

4 "Innovation Insight: The 'Internet of Everything' Innovation Will Transform Business," Gartner; January 2012.

Figure 1. Internet of Everything



Source: "Embracing the Internet of Everything To Capture Your Share of $14.4 Trillion," Cisco, 2013.

According to Cisco, IoE brings together people, process, data, and things to make networked connections more relevant and valuable than ever before—turning information into actions that create new capabilities, richer experiences, and unprecedented economic opportunities for businesses, individuals, and countries. Based on Cisco research, 99.4 percent of physical objects that may one day be part of IoE are still unconnected.[5]

Trends in technology—the dramatic increase in and the reduced cost of processing power, storage, and bandwidth; the rapid growth of cloud, social media, and mobile computing; the ability to analyze Big Data and turn it into actionable information; and an improved ability to combine technologies (both hardware and software) in powerful ways—are making it possible to realize more value from connectedness.

The Internet has evolved from connecting people and later videos, photos, and text to more recently physical objects. Using sensors, physical objects can "talk" (transmit data) to each other and even command each other to perform a physical act. As things and people become more connected, such objects will also become part of social networks, much in the same way that people tag photos on Facebook. In this way, the value of such objects will increase for both research and learning.

Since 2008, the number of physical items connected to the Internet has exceeded the number of people on Earth.[6] Internet Protocol version 6 (IPv6) provides virtually limitless connectivity and tackles the need for more addresses for the IP domain. However, there are other protocols that may serve as a basis for information flow between devices. For example, Bluetooth protocols could connect peripheral devices such as keyboards to computers with IP addresses that collect metadata on a learner's typing skills. The IP could relay metadata to the computer, which could compare users' skills. If learners need improvement, they could partake in a keyboard-based exercise to correct habitual errors.

Imagine how many other ways a learner's performance could be measured and improved through IoE. Even the most mundane items can now be connected to the web. The groundwork for IoE has been laid, and Cisco predicts that 50 billion things will be connected by 2020. IoE will connect people in more relevant ways, delivering the right information to the right person or machine, efficiently and effectively. Furthermore, if open standards are developed and adopted, IoE will enable better interpretation and use of the data being collected.

5 "Embracing the Internet of Everything To Capture Your Share of $14.4 Trillion," Cisco, 2013.
6 The Internet of Things"; Dave Evans; Cisco Blog; July 15, 2011; http://bit.ly/mVzJa6.

IoE in Education

The four pillars of IoE create a need for an education system that empowers a new generation of digital citizens who understand the technologies that underpin IoE, the societal impact of widespread adoption, and the right application of the information that is captured.

Higher education programs must ensure that the next generation of engineers understands how to design and build technological systems that reflect our altered expectations of openness and participation. In the area of computer science, the challenge is in developing new forms of scalable education that accommodate large numbers of students around the world, attract potential students with various interests, and deliver an innovative curriculum that reflects the radical changes in computing technology.

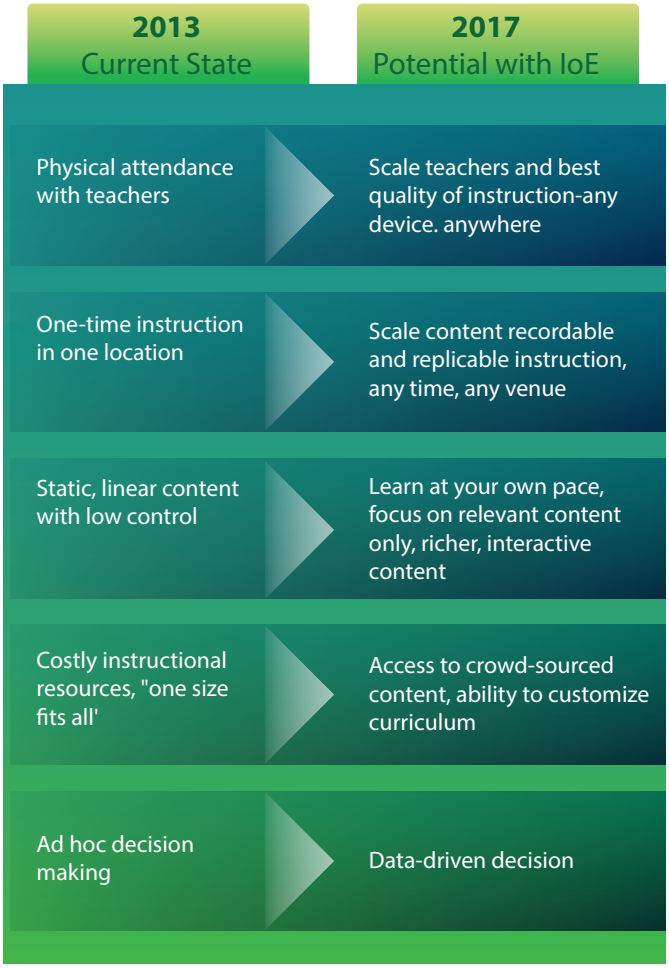
In response, the Open University in the United Kingdom revamped its undergraduate computer science curriculum and now offers an introductory course, My Digital Life, designed around IoT concepts. My Digital Life places IoT at the core of the first-year computing curriculum and primes students from the beginning for the coming changes in society and technology. Rather than narrowly defining IoT as a technical subject, the course helps students view IoT as a tool for understanding and interrogating their own world, and recognizing their role in realizing IoT's.

Another way to understand the impact of IoT in education is through the use of sensors. For example, Supermechanical's Twine[7] product–a small box described as "the simplest way to connect stuff to the Internet"–allows users to link almost any physical object to a local area network. Twine integrates sensors with a cloud-based service, allowing for easy setup. Just point Twine to a Wi-Fi network and sensors are immediately recognized by the web app, which reflects what the sensors see in real time. Even people with no knowledge of software coding can receive text and email updates on whatever items or environments the box is sensing.

The 2013 Horizon Report predicts that smart objects will become ubiquitous in higher education by 2017. With such user-friendly technology like Twine already on the market, this may come sooner for higher education, and sensor kits will be used extensively in K–12.

Cisco predicts that worldwide, IoE in education has a 10-year net present value of US$175 billion, which will be delivered through streamlined and personalized instruction, and through the collection of data for making better decisions and reducing expenditure on instructional resources. This value is based on the global adoption rate of IoE increasing from less than 5 percent in 2013 to 32 percent by 2022. Figure 2 shows developments and benefits that the shift to IoE will support in the next four years.

Figure 2. Changes in Instruction through IoE.



Source: "Connected Learning: IoE Value at Stake in the Public Economy, Cisco 2013

There are some institutions around the world where these shifts are taking place, but the transitions are not widespread. The $175 billion market value does not include improved learning outcomes and greater engagement through IoE-enabled solutions. As learners become co-creators of knowledge, using sensors to better understand physical and social phenomena; as learners with disabilities use of IoE to capture more and better learning opportunities; and as IoE increases connections to business, cultural institutions, and communities, the value of improved learning and student success, and the resulting reduction in resources could increase IoE's $175 billion net present value.

7 http://supermechanical.com/twine/

Implications of IoE in Education

Few educational institutions actively incorporate technology into learning, least of all reach out and connect to each other. And, fewer teachers share data, except for research projects. Massive adoption of technology in education is required so that the power of IoE can be realized and learning can become more authentic and relevant through engagement beyond the classroom.

Educational jurisdictions and institutions can no longer rely solely on their core competences and teacher knowledge. Instead, they must embrace—not prohibit—the devices that learners bring into the classroom and allow students to use them as learning tools to capture intelligence faster and accelerate learning.

The proliferation of mobile devices will also enable educational institutions to collect data to interpret a learner's behaviors and activities. Used intelligently, such data will result in personalized learning targeted to individual needs, learning styles, and aspirations.

There are myriad uses for technology in education, but many are piecemeal and ad hoc with little informed thinking. IoE has the potential to integrate technology with learning in many ways.

Four Pillars of IoE in Education: People, Process, Data, and Things

IoE in education is in the early stages, but some institutions are leading the way in showing how IoE can be used effectively in educating young people and the public at large. This section explores the impact each pillar has on education and what is needed to support, build, and scale some of the practices currently being planned or adopted.

People

Today, most people connect to the Internet using multiple devices and social networks. It is too soon to predict the channels people will use to connect to the Internet in the future—what is certain is that through such channels, people will be hyper-connected.

The education sector must understand how people connect to the Internet to increase their learning and apply their knowledge as a result. Time to mastery will be key knowledge gained today will be used tomorrow. Those learners who thrive will stay current and ahead of the pack. In the words of author Alvin Toffler,[9] there will also be those who know how to "learn, unlearn, and relearn." Finding the right people with and from whom to learn will be crucial: As each individual becomes a "node" on the network, people will need to know how to connect, not just to the work of leading experts, but to peers who have similar passions and interests. In this way, people will share ideas, discuss research/the latest developments in their area of study, and develop increasingly connected communities of practice. Experts in a specific area will be sought to teach classes anywhere in the world, and sharing information via streaming or live video will become the norm.

> *"Smart objects are the next generation of those technologies—they "know" about a certain kind of information such as cost, age, temperature, color, pressure, or humidity—and can pass that information along easily and instantly. Learners can now annotate them with descriptions, instructions, warranties, tutorials, photographs, connections to other objects, and any other kind of contextual information imaginable. The Internet of Things would allow easy access to these data."*[8]
>
> NMC Horizon Report

The advent of massive open online courses (MOOCs) is another step toward global education. MOOCs are aimed at large-scale interactive participation and open access via the web. Some of the world's leading universities are making their top professors available free of charge, and online forums that are linked to MOOCs will become spaces for new networks to develop and grow, connecting people from all walks of life and giving education to those who do not have access to high-quality content or instructors in their own locale.

In K–12, Khan Academy's[10] free (open) educational resources have spawned the debate on "flipped classrooms" where learners watch videos on the subjects they are studying either at home or elsewhere outside the classroom. Teachers then use class time to discuss problems, work on ideas, and encourage group collaboration. The impact such resources have on all phases of education could be significant in emerging economies where access to high quality educational resources will help support and improve teaching and learning. In many developing countries, access to localized resources is limited, text books are often outdated and expensive, and funds for developing new materials are in short supply. Additionally, access to learning beyond basic education is often limited by economic status. Therefore, free access to MOOCs and resources like Khan Academy will improve the quality of life for many people who cannot afford a formal education.

8 "NMC Horizon Report, 2013: HiEd Edition," The New Media Consortium, http://www.nmc.org/publications/2013-horizon-report-higher-ed
9 Future Shock, Alvin Toffler, Random House Publishing Group, 1970.
10 www.khanacademy.org

Students Experience Virtual Diving across Continents

Pymble Ladies' College in Australia comprises five schools with a total of more than 2,100 students who expect to connect anywhere in the world, anytime and from any device. The need to make video available seamlessly across platforms coupled with students' desire to interact with schools in South Korea prompted college directors to adopt Cisco video technologies–allowing students to connect "in-person" with experts and peers, expand knowledge frontiers, and embark on virtual tours such as visiting and interacting with a diver on the Great Barrier Reef.

"As soon as they come in, they are incredibly excited, and when they realize they can ask questions directly to someone in a diving suit underwater, they are just fascinated…anything that is going to excite students is going to excite teachers."

–Amanda Paterson, Head of Science, Pymble Ladies' College, Australia

Although perceived as disruptive innovation, these types of initiatives are not panaceas: Some argue that these resources apply a Learning 1.0 pedagogy in a Learning 2.0 environment. However, the opposite is true. These open resources have raised the debate, making educators compare the value of online learning to a campus-based experience. MOOCs are forcing universities to find more creative ways to improve the learner experience to attract and retain students. And, Khan Academy has made teachers review how they work with learners in a face-to-face environment. The same is true for technical and vocational institutions, which are now making use of such resources.

As they evolve, MOOCs will generate large data sets of information on the average size of individual MOOC registrations, the number of dropouts, attendance in online forums per course, the percentage of students who take certification assessments, and more. Such information will give institutions insight into students' locations, their reasons for taking (or not taking) a MOOC, and, if applicable, their reasons for dropping out. This information will help MOOC providers improve the development and marketing of their courses.

Furthermore, data generated from IP addresses will reveal how much time people spend on the course materials and in forums, which can help determine which factors –demographics, content, and topics – are most appealing and appropriate for a MOOC-type model. Not only will this information be useful to MOOC providers, it will also help other institutions developing both online and campus-based programs to provide a more individualized approach to teaching; and feedback on instruction, methodology, the process of delivering courses, and best practices for incorporating technology into learning. Such information will prevent students from dropping out of degree courses and help educators align curriculum to students' needs and learning preferences.

Across the education system, the ability to find experts and bring them into the classroom in real time or through recorded video is another way to increase access to and impact quality of education. IoE will help connect learners who are home-bound but capable of learning and participate in classroom courses. In addition, IoE will provide minorities and disabled learners access to high-quality learning and peer-to-peer interaction, which will improve their opportunities for greater success.

IoE can also support professional development for teachers who may adopt new learning models, as data about their practice is collected through student feedback, teacher achievements, and video recordings. This data can be used to examine the teachers' strengths and weaknesses, and form the basis for debate and subsequent adjustments to their pedagogy. Excellence in teaching can then be profiled using the recorded videos, which can be made available to other teachers as a professional development tool used to explain and spread good teaching models.

Process

Process plays an important role in how people, data, and things work together to deliver value in the connected world of IoE. With the correct process, connections become relevant and value is added because the right information is delivered to the right person, at the right time, in an appropriate way. Ensuring that young people have access to learning opportunities that meet their needs will make education more efficient, improve time to mastery, and motivate learners. Such opportunities will also increase student retention and the application of new knowledge, which is vital for future success in both work and society.

Much value can be derived from feedback on a student's performance. For example, a learner studying 10th-grade geography could observe his or her ranking in real time against all learners studying the same level geography. The process could eliminate examinations used to measure and compare learners' performance and achievement. The model of measurement could be accurate at any moment in time, providing ongoing, targeted, and personalized feedback on what a learner must do to improve his or her understanding and performance.

It will be some time before assessment, as we currently know it, is no longer necessary. However, IoE will change the way e-assessment is carried out. Mike Lloyd, CEO of Edutech Associates, conducted research on e-assessment in K–12 systems around the world and outlined a model for further developments.[11] He paints a scenario in which a learner has "…learned something significant and has verified the learning through a series of low-stakes e-assessments."[12] To gain full accreditation for their learning through some official channel, learners can access an accredited "Examination Zone," an area (or room) Lloyd suggests is "…set up to written examination standards, and monitored for honesty."

Examination Zone: How it Works

"The learner logs on to the examination system, which verifies the user through device-level biometric security, then locks down the device to ensure that the learner does not have access to local resources. The student is presented with the exam questions and types or handwrites the answers. The device pushes an encrypted version of the student's answers to an E-Exam-Ready Wi-Fi router (gateway) that relays the data to servers, which also have device-level security to verify the validity and security conditions of the student's responses. From there, the examination response is assessed and credit given in due course, with an encrypted certificate sent back to the student.[13]"

–Mike Lloyd, CEO, Edutech Associates

11 "E-Assessment: The High-Stakes Strategy," Mike Lloyd, Edutech, March 2012, http://bit.ly/19CUBju.
12 "Internet of Learning-Things," Mike Lloyd, Edutech, August 2013, http://bit.ly/1g3wPGP.
13 Ibid.

Within IoE, educational institutions will work with cultural organizations, governments, and businesses to link people, process, data, and things to maximize the relevance of education and to provide skills to the next-generation workforce. Connecting peers and bringing experts into the classroom virtually will require change-management processes and new attitudes and practices to provide students with a unique, value-added learning experience.

The "Internet of School Things"[14] is one of the first projects to explore this approach. Announced August 2013, the project—which includes eight U.K. secondary schools, grades 11 through 18—is designed to teach learners about the potential of connected everyday devices, using them to bring other subjects to life by collecting data in the areas of transportation, energy, weather, and health. The project is funded by DISTANCE, a consortium of IT companies and universities. Learners are also taught how to build their own products and sensors, easily bring them online, and monitor variables of their choosing.

DISTANCE plans to create an information hub in the cloud that will enable the consortium to identify the incentives required to encourage educators, students, and businesses to share certain types of data openly for the first time. A platform and service layer will connect schools with third-party service and application providers, who can then supply Internet-enabled measurement equipment and interpretation software. In addition, DISTANCE will develop a range of apps and data visualizations that can be collected by schools, together with comprehensive curriculum-based activities for pilot schools to trial.

100-Year-Old College Applies IoE to Physical Access Process

At Bournville College in the United Kingdom, Cisco Physical Access Control technology simplifies the process of managing access to classrooms, offices, common areas, school cafeteria and convention center, and more—400 doors total—while monitoring foot-traffic patterns on the main campus. Students, faculty, and staff are given badges at the beginning of the school term, and visitors receive temporary badges when visiting. Each group is assigned different privileges, enabling the college to protect people from wandering into restricted areas or places where they might not be safe, such as the motor vehicle area. The system also keeps a log of attempts made to access areas where the badge holder is not allowed and then sends the data to the college's management team for investigation.

The system also controls the doors of a nearby administrative building, reducing the costs of purchasing a separate system and hiring staff to manage it. The IoE-based process helps create a safe learning environment by keeping visitors from student areas and enabling IT to remove student-access privileges with just a few clicks when students are no longer enrolled. In a recent internal survey, most students indicated that the system made them feel safe and secure. High levels of security are demonstrated across the college, with 95 percent of students agreeing "completely" or "mostly" that the system is an improvement in security over the previous year.

Council Rock School District Saves $8.8 Million on Energy

The Council Rock School District (CRSD) is the ninth-largest in Pennsylvania, with 1,400 full-time staff, 12,000 students at 10 elementary schools, three middle schools, and two high schools. CRSD's energy-savings program, "Go Green," helps the district apply monies saved on energy to other areas of its operating budget—funding programs or staff that might otherwise be subject to cuts. Through a state-of-the-art networking infrastructure, the district integrated its heating, ventilating, and air conditioning systems to monitor, control, and report energy use of network devices and facilities equipment. The process enables IT departments to power-off devices and computers remotely at a given time, wake up devices for maintenance work, or turn off devices during holiday and vacation periods. Cost savings generated from this program have been instrumental in helping the district continue to deliver high-quality education to its students. Since the program was launched in 2003, the district has cut power consumption by more than 40 percent, saving $8.8 million in 2012.

"EnergyWise gives us insight on usage and control of devices, and then helps us with the other half, which is persuading people to alter their behavior so that we do things better and gain efficiency."

— Matt Frederickson, Director of IT, CRSD

14 http://gigaom.com/2013/08/20/the-internet-of-school-things-comes-to-the-uk-to-teach-kids-the-power-of-data/

Process is also key in tracking attendance and use of virtual learning environments, purchasing books, collecting data on study habits, and managing physical access to areas on campus. Ultimately, this data can be incorporated into a full-fledged analytics system to customize students' education.

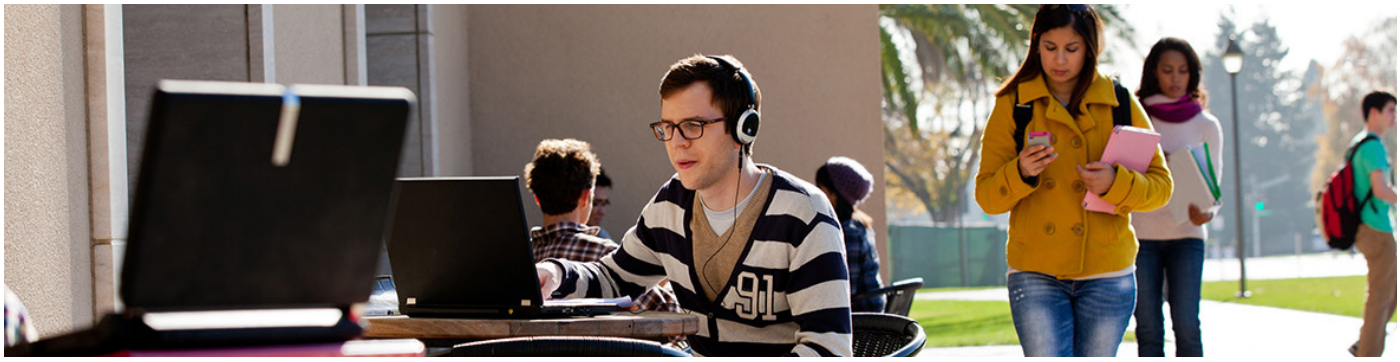
Connecting people, data, and things requires efficient processes not only to evaluate the outcomes of those interactions, but also to enable people to make better/more informed decisions that capitalize on efficiencies, costs reductions, energy savings, and lean management, as evidenced by the Council Rock school district in Pennsylvania.

Cultural institutions are also leading the way in changing standards practices and finding educational applications for IoE. For example, the Cleveland Museum of Art[15] in Ohio is embracing IoE to lure new visitors. In an attempt to make the museum more appealing to young people, the museum's Gallery One blends art, technology, and interpretation to encourage visitors to explore its permanent collection. Gallery One has a range of technology-based activities, including one that invites visitors to match the facial expressions in a painting to their own and then share photographs of the results via social media. In addition, display screens alongside original works show people how the pieces were made. The idea is to engage visitors with the object more fully—rather than have them view the art and then quickly walk away. Information captured from visitors' interactions with the screens helps the museum decide which pieces to display or change based on the nature/amount of interaction with each piece.

Another museum-based project is QRator,[16] led by University College London (UCL). QRator allows visitors to type their interpretations of museum objects into their mobile phones using a special application and then send their information to the museum, where their interpretations become part of the object's history via an interactive label system, which displays their comments next to the artifacts. Developed by UCL's Centre for Advanced Spatial Analysis, the project is powered by "Tales of Things,"[17] which catalogs physical objects online, bringing more interactivity and collaboration to the museum experience.

Gallery One and QRator are two examples of how IoE encourages crowd sourcing to deepen one's knowledge in an authentic setting beyond the classroom.

15 Gallery One, Cleveland Museum of Art, http://www.clevelandart.org/gallery-one.
16 http://www.qrator.org
17 http://www.talesofthings.com



Data

As things connected to the Internet evolve, they will also become more intelligent, thereby providing more useful information. Rather than just report raw data, connected things will soon send higher-level information back to machines, computers, and people for further evaluation and quicker decision making.

The implications of this in education are enormous. For example, as part of their studies, learners could tag physical objects, collect data about those objects, and then feed that information to other programs for analysis, improving the accuracy of their research. Learners could also access data from research initiatives, monitor programs on oceanography or climate change, or watch animals in their natural habitats via live webcams then collect data on their movements through sensors attached to the animals' bodies. The authenticity of such data will have a huge impact on learners' interests. Furthermore, collecting data remotely will also help people reduce their carbon footprints through fewer field trips.

Research has shown that access to real-time information and engagement with experts truly impacts learning. One example is the Cleveland Clinic[18] in Ohio, where human biology is taught to secondary schools through video conferencing based laparoscopic surgery. One surgeon talks about the features and functions of the heart and the procedure while another performs the surgery. At the same time, students can ask questions. The result is increased motivation, with more learners aspiring to become nurses, doctors, or medical technicians.

In addition to ensuring accurate research and working with and manipulating real data, learners could also contribute their content to data banks, becoming members of expert communities in various research projects—from climate change, species identification, and archaeology to more. Sharing datasets with others around the world will enhance and extend students' learning experience, authenticating their research through active engagement with other researchers.

Not only are learners in contact with researchers, they are working with them to help solve local and global problems. For example, if learners are monitoring how much time they spend cycling to and from school and the routes they take, the aggregated data collected from students across schools in a city or region could be used to persuade a local authority to build more bicycle paths. Because the data collected is specific, the location of bicycle paths and scheduled production can be quickly and easily determined through authentic, crowd-sourced data. This approach is already underway in Glasgow, Scotland.

The Glasgow project will be integrated with school curriculums, allowing learners to develop the skills and knowledge needed to produce and use data, as well as solve local issues with emerging technologies. Through the use of IoE, activities like the mapping project will help learners understand the consequences of their actions at an early age, as they can see in real time how certain behaviors, actions, and habits affect the environment. By making the learning context "real," local, and fun, young people will be more engaged with their community.

Making Cities Smarter, Safer, and More Sustainable

Through its Future City[19] program, the city of Glasgow is developing a school mapping project that will enable young people, parents, and teachers to map out which mode of transportation they use, the routes they take, and the distance they travel to school—and then combine the data to create a comprehensive visualization of the school's travel network. Tools such as mobile apps, interactive games, and an online school travel planner will inform schools and communities on local changes in travel arrangements to encourage active modes of travel. The maps will be published online with the council's open data manifesto, and will allow schools, local authorities, community councils, and transportation agencies to make smarter decisions on road safety and "active travel"[20] programs.

18 Personal exchange with Ros Strickland, Cleveland Clinic, 2009

19 http://futurecity.glasgow.gov.uk

20 www.glasgow.gov.uk/index.aspx?articleid=4000

IoE can also enable students to track and analyze their own data for adopting healthier behaviors. A number of reports from around the world express concern about obesity and the sedentary lifestyles of young people. For example, the National Child Measurement Programme[21] in England estimated that one-third of children in the final year of primary schools (age 11) are either obese or overweight. Another U.K. study[22] based on data from accelerometers given to nearly 6,500 7-year-olds found that half were sedentary for 6.4 hours a day. The structure of the curriculum and school day is partially to blame. However, these children are not in school all day, so education is necessary to help increase their levels of physical activity—at least one hour of moderate to vigorous activity a day—and encourage them to adopt better eating habits.

IoE can help: As part of an educational activity linked to mathematics, science, and physical education, learners can use sensors to monitor their daily activity by collecting data on how far they walk or run, their heart rate, and other metabolic functions. As a class project, human biology comes "alive," as shown in the Cleveland Clinic example, and leads to greater engagement. Biology classes become more interesting as learners use the data to motivate each other to adopt healthier lifestyles.

Focusing on the individual's well-being can set the stage for other areas of the curriculum. In addition to monitoring physical activity, apps such as Edomondo[23] provide a social networking site for sharing activities and achievements, therefore helping ensure that fitness and health feature strongly in a young person's daily life.

In the United States, United Healthcare is testing a project involving games and sensors in three schools.[24] The healthcare provider is developing a gym-class version of the popular video game Dance Dance Revolution. Up to 48 young people copy the dances displayed on a large screen, while sensors within the wireless dance platform record data on their level of performance. The information is tracked over time and shared with teachers, parents, and learners. For schools where sporting facilities are limited, this game provides an alternative way to exercise. The company is also developing a beta project that turns an Xbox Kinect into a physical therapy "coach"[25] that counts repetitions and monitors the body's movements to ensure exercises are being completed correctly.

IoE takes data-driven decision making in education one step further, encouraging innovation that motivates and excites learners, turning passive learning into active learning, informing educators about students' lifestyles, and helping teachers develop better curriculum and assessment structures.

21 http://bit.ly/1bK5vvw
22 http://bmjopen.bmj.com/content/3/8/e002893.full
23 http://www.endomondo.com
24 http://bit.ly/10fmdGK
25 http://bit.ly/1ebP4oY

Safer Schools Increase Student Attendance

For the citizens of Oakland, the safety and security of their young people is top priority. In 2005, violent incidents throughout the city negatively impacted student attendance. Students within the Oakland Unified School District were becoming disengaged and skipping classes because they felt that that their school was an unsafe learning environment. Through the implementation of Cisco surveillance technology, special cameras and sensors were placed in the schools, allowing principals, security officers, and operations leads to preconfigure school surveillance cameras remotely to increase accuracy and timeliness of emergency responses. By connecting these devices to school networks, school administrators have excellent coverage of all entrances, exits, public areas, parking lots, bus lanes, and sport facilities—making students feel more secure and less likely to skip class.

Things

Things are physical items that can be connected to both the Internet and people via sensors. Sensors give things a "voice": by capturing data, sensors enable things to become context-aware, providing more experiential information to help people and machines make relevant and valuable decisions.

For example, smart sensors are being used today in bridges to monitor temperature, structural integrity, and traffic density in real time. In this way, students can learn physics using their portable devices to collect and observe the bridge at peak traffic times. Capabilities like these have huge implications for learning and the potential to help transform pedagogical practices.

Imagine if things could to talk to each other, forming a community of things—objects will exhibit certain behaviors based on stimulus from their surroundings. If things could share information that improves their functionality, sensors could be embedded into everyday items enabling them to upload information to the Internet.

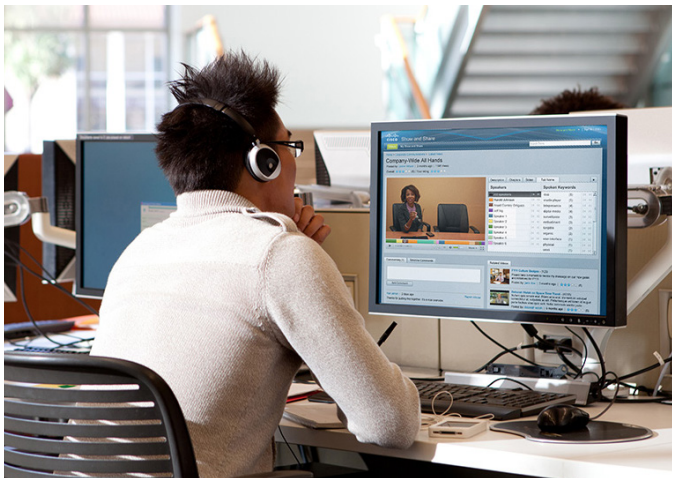
In education, IP-enabled sensors could be attached to artifacts such as the Allosaurus skeleton to monitor temperature readings, condition, or location of the object in real time, providing a constant stream of information to archaeology or history students/departments.

In research, there has never been a better way to study hard-to-reach animals than with sensors. Spanish biologists recently used a new RFID system[26] to observe marine life in salt water—a medium that tends to disrupt other forms of radio communication. The information can be made available to educators, helping them provide live data to learners to increase their understanding and update them on the latest findings and research.

Sensors also play a pivotal role in the area of student safety. In Oakland, California, security cameras and motion sensors are integrated into the schools' networks to monitor facilities, making sure the learning environment remains a danger-free zone for students, teachers, and parents.

Special education is another area where sensors can have a huge impact. In Australia, sensor gloves are being explored to provide feedback to children learning Auslan sign language from a computer. A learner attempts to sign while wearing the glove; the information is fed back to the computer, which gives the learner feedback on the accuracy of his/her signing. Researchers believe that a learning system could be developed only if the feedback is timely and accurate for a wide range of learners.

Other products such as headsets help learners who have Attention Deficit Hyperactivity Disorder (ADHD) and/or are easily distracted. Equipped with sensors, the headsets detect brain activity and offers rewards when a learner demonstrates improved concentration. The link between real objects (things) and web-based information about them is a significant step for education and will create deeper understanding across curriculums.



26 http://www.mdpi.com/1424-8220/11/10/9532

Key Factors for Successful Implementation of IoE in Education

IoE has huge potential in education. Three main factors must be addressed to ensure widespread and successful adoption.

1. Security

IoE security will become an enormous issue across all markets—particularly in education. Without assurances, pervasive development of IoE will not take place across educational institutions. Information must be available—yet confidential—when needed, with the owner of the information deciding which people, groups, or organizations may have access to it. The questions for K–12 will be, "Is security the domain of the learner or the domain of the educational institution?" "At what age will learners be able to manage their own personal data?" "How will security issues impact the ability to make data-driven decision making possible?"

Embedded devices will lead to complex networks of people and things in both the public and private sectors; such devices will likely create new relationships among people and computers. Balance must exist between understanding the positive impacts discussed in this paper and generating awareness about the risks to privacy and security. Both educators and learners will need to have a better understanding of ethical issues and the risks of IoE, as well as ways to mitigate those risks. Personal and communal data will need to be treated differently, and the individual's privacy will have to be respected.

2. Data Integrity

Integrity of data must also be assured, as well as its accuracy, authenticity, timelines, and completeness. Success will be predicated on an "open platform" that allows all partners working together to use the same baseline technologies. Educators will need to work closely with government to ensure the development of IoE in education; at the same time, government must preserve the safety and security of its citizens.

3. Education Policies

Policies that encourage adoption of technology in the classroom and its effective integration into curricula are crucial. Such policies must include sound change management practices among educational institutions to reduce the barriers to technology adoption and increase its scale. Professional development programs for educators should incorporate IoE tools to encourage early adoption and help educators develop innovative methodologies and appropriate pedagogies for the learning environment.

Conclusion

There is tremendous value in connecting the unconnected with intelligent networks across education. This paper demonstrates IoE's potential impact on making education more relevant, engaging and motivating learners, and enabling faster time to mastery. However, to realize the benefits from connecting people, processes, data, and things, reliable connectivity and continuous access must be guaranteed. Additionally for IoE to be accepted, both policymakers and educators must be well-prepared not only to exploit, but also to understand potential risks.

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