Universities X.0: integrating new educational and research tools to build networks of ideas, collaborative knowledge-builders, and learning spaces to transform the world into an evolving global campus open to all

François Taddei
Centre for Research and Interdisciplinarity
Paris-Descartes University
taddei@necker.fr

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Abstract

In this fast-changing world confronted with so many crises, universities are expected to train people able to seek and implement approaches to the challenges of the 21st century. Over the coming years, a new university will need to be opened every day and a new professor trained every minute to meet the needs of new millions of students around the world. To simultaneously increase the quality and quantity of education provided under severe budget constraints will require continuous updating of the way higher education is dispensed. Digital tools may be part of the solution if they are specifically designed for education rather than merely being adapted to it, and if we consider them in a permanently evolving context in which both on-line and real life interactions are integrated to maximize learning and creativity in students. Universities should not only produce open educational resources and open-source software, but also permanently train future generations to use such tools optimally, to integrate tools that already exist, and to develop new tools tailored to the needs of coming generations of learners. To achieve this goal, universities could create new interdisciplinary education and research programs specifically aimed at developing new learning tools and reinventing education for the 21st century. They should train learners to make the best use of both digital and face-to-face interactions during their university years and throughout their lives, as well as to become creative, co-operative knowledge-builders.

New integrated tools could contribute to the simultaneous development of co-evolving networks of learners, ideas, and learning spaces dedicated to interaction and to the incubation of innovative projects. These intertwined networks would allow students to locate, store, exchange, and discuss relevant information with their peers and mentors, and together with them develop creative projects on line and in real life. Understanding the conditions that permit the integration of education and research in the digital age and that enable everyone to contribute to knowledge-building will allow us to revive the ideals of those who founded our universities in the past centuries.

Challenges for the universities

Universities are among our most important assets for use in facing the challenges of the third millennium. As places of higher education, social experimentation, research, and culture, universities can help forge a sustainable model of development to cope with the multiplicity of global crises. Over the centuries, and under much constraint, universities have progressively refined how they dispense education and conducted research. They had to fight for their independence and to modernize their curriculums. Now they face major new challenges in a world that is changing faster than ever before. But their predominant mode of teaching is not evolving quickly enough.

There are more than 100 million students throughout the world studying in institutions of higher education. Considering the pace of demographic growth and the relationship between economic modernization and a well-trained workforce, it is estimated that the number of students must double over the coming years. To face this increase would require that a new university be opened every day for around two decades. The costs of the best universities and the scarcity of well-trained researchers and professors is such that doubling the number of universities while maintaining their quality seems unlikely unless we radically rethink how to provide higher education. There is great hope that new technologies of information and communication will be able to contribute to this effort; however, the success of these technologies has so far been limited in higher education. Clearly, technology cannot be a solution by itself; it will have to be integrated into a coherent new framework. In view of these considerations, we cannot underestimate the importance of the education–research–campus life triangle, that combines the key ingredients for success in the best universities. Clearly, when one of these sides is missing or not as well developed as it could be, the quality of the other two suffers.

Given that the overall number of scientific publications multiplies 100-fold every hundred years (even faster in some emerging disciplines and high-tech sectors), an important part of the knowledge available in textbooks today is obsolete. University education cannot be up-to-date unless students are actively involved in research, exploring the frontiers of knowledge. Solutions to most real-life problems today require skills and tools developed by people working in disciplines different from those in which they are competent. Innovative research requires an ability to interact with people from different backgrounds. However, not all universities possess the broad spectrum of disciplines that must be taught in order to qualify people for the increasing fraction of jobs for which interdisciplinary education is necessary, or to help students and researchers find new research projects at emerging interfaces. Moreover, many universities do not have a real campus and associated student life. Their ability to foster informal interaction among peers and mentors and to host projects is therefore very limited. On the other hand, when one looks at companies that did not exist a few years ago that now are worth more than 10 billion US dollars, one notices that they are usually high-tech firms founded on a few interdisciplinary American campuses by people who were around 26 when they launched their projects. It is for these very reasons that competition is more intense than ever among universities and countries to attract the best students, to build the best campuses, and to generate the best research. Yet it is clear that these elitist strategies increase differences between those who have access to the top places and those who do not. This existing situation helps only a tiny fraction of the total

student population.

Interestingly, the Nordic countries succeed very well in economic terms, in innovation, and in the ability to build the most advanced knowledge societies. Nordic countries have better scores and much less variation in university rankings than the US or any other country. Far from having developed an elitist model, as some countries have, they offer the best education to every citizen and have record numbers of people entering their universities and benefiting from life-long learning. They serve as a model for many reformers throughout the world.

Before we could extend such a model onto the global scale, we should learn from them. This paper is not meant to extensively review the Nordic model, but does aim to learn from their successes. Danish students are allowed to access books -- and even the Internet -- during exams, so it is clear that it is not memory that is being assessed, but rather more advanced cognitive skills, such as learning to learn, critical thinking, and creativity. The Nordic countries began to reform their educational systems decades ago and improve them thanks to good research on education. They constantly update their educational system by encouraging teachers and students alike to take initiatives. They foment interdisciplinary programs and project-based learning that boost students' creativity, self-confidence, and team-building efforts, as well as their ability to learn how to learn and -- most importantly -- to learn how to *unlearn* obsolete views. There is has a strong culture of cooperation, creativity, horizontal interaction, questioning, and trust in the Nordic countries, which seems to have very well prepared their students and citizens for the 21st century.

In the following paragraphs we will review some of the promising changes that develop on the web, in social interactions, in science, in education, and in university campuses. We'll used the *Terminology 2.0*, a term borrowed from computer software, that describes a new version of an existing system, based on a new paradigm. We will discuss how these reforms could become an economically sustainable, key dimension of reform and finish by assuming the perspective of future generations of learners, who must become cooperative, creative knowledge-builders.

Web 2.0 and beyond

Some of the Nordic success may be attributed to the ability to train students for a changing world, their drivers thriving on what is known as *web 2.0*, in which everyone can contribute to co-operative knowledge-building. Contrary to the hierarchical web 1.0 world, in which only those few who are endowed with power can control information flow and express opinions, in the web 2.0 world, anyone can not only access, but also produce and exchange information. In this environment, nobody knows everything, everybody knows something, and everyone gains by exchanging ideas. This explains the successes of creative common projects, such as Wikipedia[3] . Taking initiatives and developing projects that improve one's own knowledge as well as that of others results in a virtuous circle that can only amplify in time, as more freely available open resources and open software become protected under new creative common licenses.

Web 3.0 will include more and more semantic tools, mobile activities, interactions

among machines, sensors, and software that humans will continue to develop, opening many new possibilities for education and research. As change continues to accelerate, some people are already trying to invent the future and are discussing web 4.0. It is clear is that changes will continue to accumulate in a world that is changing faster and faster. The title of this paper refers to *University X.0* in order to emphasize that universities not only have not only become more 2.0 by integrating more social tools and interactivity, but have also adapted to the flow of change and mutated into rapidly-evolving structures, exploiting these opportunities to face the challenges described above.

Adopting a culture of change is the key to survival in this fast-changing world. However, it is not enough to follow the latest technological fashions without thinking about the role of universities in the 21st century. The first modern university was founded in the 19th century by Humboldt to link research with teaching, while granting freedom to teachers and learners and reinventing new curricula based on the arts and sciences instead of religious doctrine. Over the past two centuries, mass education in our universities led to specialization within disciplines and resulted in a growing role for bureaucracies and rigid hierarchies, too often at the cost of the academic freedom of learners and teachers. As the democratization of university access becomes increasingly necessary, technologies can help revive the Humboldtian ideal by increasing freedom and strengthening the link between education and research, allowing students to educate themselves by experiencing research. Most technologies were developed to serve applications in business and entertainment, not because of their educational value. We need to create technologies that are specific for education, not merely adapt technologies that were developed for other purposes. By rethinking the educational needs of a digital world then designing technologies for education, we would take an important step toward the strengthening the future of our universities.

Cost and benefit of upgrading education systems

Considering how much it costs to construct a university, the total budget (the cost per student is between several thousand and tens of thousands of Euros) multiplied by millions of students is mind-blowing. If we add the budget for life-long learning and elementary schools, the total is even more astronomical. Using a tiny fraction of these resources to develop new technologies and concepts for improving the efficiency of education can only yield a very large return. As a bonus, it may allow us to face the challenges, such as those related to the global crises already mentioned, that only a well-educated population would be able to do successfully.

Thus, investing in what is necessary for attracting the best brains in the effort to adapt higher education to the 21st century should be a priority for every government that is serious about strengthening its knowledge society. New models must be devised for rewarding and maximizing the efforts of those who produce knowledge and design the requisite tools. One possibility is to include this production effort in the requirements students must satisfy. Since the capacity to communicate complex ideas to a less-educated audience is one of the best ways to master such concepts, this approach would benefit not only the audience, but also the student-communicators themselves, who would then be

able to use these skills elsewhere. Such a strategy would help produce such resources at nearly all levels and in all fields. In the same way kids and adults contribute to Wikipedia[3] with the help of peers and under the guidance of more experienced contributors, everyone can contribute to the creation of educational resources in the fields in which they study.

Innovative rewards in terms of reputation, credits, diploma, money, fun, a sense of sharing, and participating in a global project (the main driving force for Wikipedians) could be developed. A new form of virtual currency, the "neuro" (numerical euro) has been proposed, which would be "paid" by learners to the sites where they have learned relevant knowledge. Receiving *neuros* would increase the visibility of knowledge produced. The conversion between *neuros* and euros would allow knowledge producers to reinvest in further production of useful resources. One can thus imagine that the knowledge itself, as well as the software producers will thereby obtain credit according to the number of people who have seen and appreciated their work, as is the case for scientists today. Student festivals and "coopetitions" (co-operative competitions), in which participants are encouraged to cooperate with other teams, have also been proposed. Contributors would be invited to present what they have developed, thereby increasing conviviality, creativity, and a sense of sharing among cooperative and innovative knowledge-builders.

Funding for the remuneration of knowledge-builders could derive from a mix of personal, public, and private investment; for instance, companies could pay to update the knowledge of their workforce, foundations could decide to support ground-breaking innovation for philanthropic reasons, and governments could pay for those who themselves could not afford to pay, as well as benefiting from a well-educated population, just as they fund schools and universities now.

Campuses of excellence must not be devoted just to training the "happy few" and conducting the best possible research, but also to finding ways for promoting the comprehension of their research results and educating everyone. If all citizens are to benefit from the advances made in prestigious institutions, the allocation of significant public resources to them must be linked to their willingness to endorse such roles. In addition, this will even help these institutions to make faster progress, not only in better educating their own students, but also in improving their research, since science is the most well known model of collective knowledge production, and it seems that science 2.0 can make it even more efficient.

Science X.0 and beyond

Is the yield of research greater when more people are invited to participate? The answer may be that in the 21st century we need relevant contributions that are a natural extension of how modern science functioned in the 20th century, but with significantly increasing collaboration. Another, more precise question may be, "Are relevant contributions to science reserved for an elite, or can science be made accessible to ever-larger circles of contributors?" Future investigations will shed new light on conditions that are necessary and sufficient for productive opening of research projects. Science 2.0 projects are just starting, but some have already produced impressive results, indicating that well-designed projects may enable many relevant contributions to be crowd-sourced. Data massively

produced by anyone on a cell phone (they already can record sound, position, and images, and will soon be able to record the chemical composition of the air or serve as a microscope) or the Internet are being used on an unprecedented scale to analyze not only what goes on in labs and hospitals, but also outside, documenting evidence of global warming, species migration, the diversity of bird songs, the progression of epidemics, or frequent drug reaction patterns. It remains to be seen whether this progress will be characterized just by more data, or if new forms of collective digital curation will emerge.

Science 2.0 goes beyond opening data production to all; it also invites everyone to contribute to the analysis and construction of new knowledge. The *polymath project* was launched by a top mathematician who couldn't solve a challenging mathematics question. By describing the question on his blog, he progressively attracted more and more people, including not only professional mathematicians, but also students and even a high school teacher. Their collective effort resulted in the resolution of this very difficult problem at unprecedented speed. In astronomy, the "galaxy zoo" couples Internet users' interest in the stars to the unmatched human ability to recognize patterns for classifying galaxies. In the "fold-it" game, players can fold proteins, enabling them to solve problems scientists are struggling with and computer are not yet able to do. In *fab labs*, one can learn to fabricate any object, including 3-D printers that can partly reproduce themselves. In synthetic biology, the iGEM competition has enabled undergraduate students to produce thousands of open wetware bio-bricks and assemble them in a manner akin to what people do in software, electronics, and robotics. In such projects, participants not only contribute to progress in science, but also acquire an up-to-date education in their specific fields, and can develop meta-skills (such as critical thinking, questioning, and problem-solving) that are quite generic and will be of considerable help to them in the future. Such examples are currently flourishing, and there is little doubt that they add invaluable an dimension to the education of those involved. Additional proficiencies include working in interdisciplinary and heterogeneous teams and in project management, which are hard to acquire in classical formal education and which they are likely to need in their professional and personal lives.

Interestingly, people who contribute to such open projects or to open-source software benefit from a new mode of recognition that goes beyond formatted diplomas and opens doors to future employment or to the pursuit of further education. Inviting them to present results obtained by their teams at festivals and competitions in which they are encouraged to share their advances is both very rewarding and very efficient in attracting other cooperative and creative knowledge-builders to contribute to such development. In addition, people who exploit crowd-sourcing for their research get help from many brains, which can accelerate their work. Institutions that are involved in research and those that dispense education should fund joint efforts that generate synergy between them, instead of giving the impression that they are in competition with each other, which leads scholars to choose between teaching and research.

New tutorial modes for open-ended projects may be an interesting way to test the possibility of introducing students to research questions in a well-structured environment. The key to accelerating this movement is recognizing the necessary and sufficient conditions for achieving efficient research project crowd-sourcing, thereby attracting many curious minds and combining Humboldtian

ideals in new ways.

Open contents and open-sources of tools are common characteristics of science 2.0 and education 2.0 projects. They are essential for facing challenges in science and education and probably represent the most efficient use of public funding, since they result in continual upgrading of tools and knowledge produced by the collective intelligence of users and developers, integrating the progress achieved elsewhere quickly and efficiently. In theory, everyone can contribute to such developments; if we want to enable more people to do so, we must provide them advanced training in the use of digital tools and in the development of open resources.

Education X.0 and the Socratic method in the information age

A growing number of educational and training courses are available on line today without charge. Millions of students are attracted to these courses, which they can follow whenever and wherever they want, at their own pace, putting more emphasis on the parts they choose.

The validation of academic credit for knowledge acquired on line or in informal settings is increasingly recognized by individuals, companies, governments, and graduate school programs. As institutions become more specialized in online resource research or production, or in the assessment of standards, some see such changes as representing additional challenges to classical university teaching modes, of which they predict the demise. Yet universities that also provide a rich campus life and good, hands-on research opportunities may still remain attractive. The best compromise has been found to be a mixture of online and real-life interactions, which is probably one of the major reasons why many online attempts are only second choices, since they provide much less open interaction than real-life exchanges. The question we will pursue here is how to optimize such a blend so as to offer the best possible learning experience for all students.

Since today's students are "digital natives" much better able to use the web to communicate with their peers and for entertainment than earlier generations, we presume they also know how to use it for education and research. However, when we probe their knowledge and ability to use the tools required for those purposes in a critical and effective way, we find that their experience is usually very limited, except for obvious search engines and Wikipedia[3] . Furthermore, it is not clear that multitasking is necessarily the best way to concentrate long enough on a problem to be able to fully grasp it and devise innovative solutions.

To get the best of the digital world may be even more problematic for economically disadvantaged children. Although web access is apparently a positive factor in anyone's education, it is more useful for children of families with a higher educational background, clearly increasing the gap between them and the disadvantaged. Hence, teaching every child and student to efficiently use the web should be an educational priority, especially for the least favored. Our discussion is centered on the university level, but as described in the OECD report mentioned above, we need to train all children in a way that will maximize their learning abilities and the interest of those who are motivated by the

intellectual challenges encountered in higher education.

Universities could also provide advanced training for future teachers, as well as help those employed today to update their skills. Teachers should not only be taught about the latest advances in their fields, but also be made aware of the latest practices and progress in education science and in pedagogical tools, in order to be able to effectively pass this knowledge on to their students. Teachers may know the intricacies of the latest high-tech tools less well than their students, but they would be able to help students make the best use of them, since they can teach relatively inexperienced learners how to take a critical stance with respect to data and information gathered using these tools. They could discuss with students how to go from data to information, from information to knowledge, and from knowledge to action, while critically questioning the whole process and its implications, helping students to see which data is important and to understand how reliable data and information should be produced.

In order to provide the best higher education to the most students, our top priority will be to train the next generation of concept-creators, invent effective research tools, and develop new technologies for fully achieving the digital potential needed to improve education. We need to create new education and research programs to which every discipline will be invited to maximally contribute and in which students and researchers can develop interdisciplinary projects. Thus, as pioneered at MIT, 21st century universities should not only make the content of lectures and courses freely available to all online, they should also develop new research tools and technologies for better educating students and training them to use the web in an efficient way, to learn how to learn, and to navigate without getting lost in the ocean of digital information (the web is so large and dynamic that today no one can count or even map the total number of pages it contains.)

Tools and resources are currently underused, in part because the people who developed them too often consider it enough just to make them available online. These tools were too seldom designed to match the needs of students from diverse backgrounds or those of education professors. Too often they are scattered around the web and viewed as mere digital versions of classical frontal teaching, without taking into consideration the will of the learner to interact and without fully utilizing the potential of 2.0 or 3.0 technologies. Since they are insufficiently integrated and do not integrate a common vision of what digital education should achieve, despite the goodwill of those who produce them, they are far from providing as much as they could.

What vision of 21st century education will emerge remains unclear. Socrates knew only that he did not know; when we analyze his contributions, some of his ideas on education appear amazingly modern for someone who lived in an ancient democracy that still had slaves. He did not like books, because he thought they gave those who owned them the illusion of possessing knowledge. He would probably not be sure that a copy-and-paste of the first result that comes up in a search engine query is the best way to promote the kind of questioning for which he is famous. According to Socrates, to go from information to knowledge, requires interaction. The web provides much information and many interactions, but the problem is how to favor the relevant ones and to master the critical thinking that enables one to recognize them. In other words, today's challenge is to adapt the Socratic method to our information age and to invent

what could be termed *maieutics 2.0*, in tribute to Socrates' midwife mother, who helped women to birth babies, as well as to Socrates himself, who helped ideas to come to life.

Aesop's tongues were fabled to bring about the best or the worse, because of heterogeneity in the quality of what can be said. This is also true for printed texts and digital content. Not every item on the web is relevant and not every new technology necessarily improves the planet. Being able to sort the most relevant from the less has always been a challenge. The scientific method is one of the most well validated ways we have to evaluate the relevance of information: testing a hypothesis by interacting with nature. An interesting new opportunity offered by the digital world is the ability it affords to simulate nature, allowing learners to mimic the scientific method via digital interaction in scientifically designed simulations, which have the additional benefit of being inexpensive and risk-free. However, once again, to make best use of the potential of simulation, one must not only have programmed it well, but also have learned how to use it efficiently.

Public debate in the agora was also frequently used in ancient Greece by those seeking knowledge. In the18th century it was in literary *salons* that intellectuals discussed the latest books agitating their minds. Today's digital counterparts, such as wikis and forums, are less elitist, in the sense that many more people can contribute to discussions. Wikis allow everyone to get closer than ever to one of the utopias of the Enlightenment: the creation of a universal encyclopedia freely available to all people in their native languages. These tools and many other online interactions clearly allow one to explore what there is, debate what they find, express their opinions, and even contribute to an updated version, thus to the construction of knowledge. Active research has always been a place for intense debate. Since the implications of scientific advancement have an increasing impact on our lives, the ability to understand the logic of these debates and to contribute to them is more necessary than ever, if we are to make collective educated guesses about such complex and controversial issues as the climate, ecology, and health.

Another utopia of the Enlightenment pioneers was universal free education. We are very far from having achieved this idea today, but we can hope to get much closer to it if we use our collective intelligence to invent the future of education. Technologies can be part of the solution, but they will not be enough if we do not include the human dimension – creativity, collaboration, the passion for learning and interacting – and if we don't seriously reflect on how to improve the efficiency of education.

Campus X.0

In trying to understand the difference between what the best universities provide and what today's web offers, a simple question comes up: "If MIT lectures are available online, what is the advantage of being physically present on the MIT campus?" A variety of answers to it come to mind, which for reasons of brevity we will not discuss here. We would rather ask a complementary question: "What can we do to reduce the gap between what is offered on the web and what may be found on a world-class campus? This point is crucial for us to simultaneously increase the quality of the average student's experience and to increase the total number of students, which must happen. New summer schools, conferences,

research and training programs, etc could be centered on figuring out how to educate students in the 21st century. This approach would address the above questions, as well as related ones, such as "What can we do to offer a lot more people a bit of what Oxford or Cambridge tutors and colleges offer to the happy few?" If we accept Socrates' conclusion that interaction is necessary to have access to knowledge, it is clear that the quality of relevant interaction in such places is likely among the very best. The informal exchange of ideas and the ability to develop networks and to create common projects are what attract students to campuses and professors to conferences where there is a high density of such quality interaction. How can one promote higher quality interactions using the web and the coming generations of NTIC technologies? In fact, if we exploit the full potential of the digital world, it can play an important role, since it doesn't limit access to information available in a particular field and doesn't constrain interactions geographically. Telecommunications abolish distance; therefore the local density matters less than the total number of ideas and thinkers that can be globally gathered. The new technologies of information and communications may be used to locate relevant information that is suggested to digital learners according their interests, which need not necessarily be specific. It is possible to do this because the information they view is locally linked to other ideas in *Idea Space.* For instance, digital bookstores recommend books and musical websites propose pieces of music that you do not know but that people with tastes similar to yours have purchased, as evidenced by something you have already bought. This may not be as personal as a professor or a friend recommending something for you to read or listen to, but the quality of such recommendations improves with the number of users – and can reach much further than any brain.

Similarly, the digital world could go even further; for instance, on-line conferences and readings with *idea-mates* who have visited the same academically relevant sites, thus share similar interests regardless of where they are located. Beyond local relationships among classmates, software may identify like-minded people of related motivation anywhere on the planet and allow them to interact first online and perhaps later in real life, creating networks of idea-mates based on their proximity in idea-space. Finding idea-mates is especially important for the creativity we need in facing the challenges of the 21st century. Even if everyone were to fully develop their creative potential, creators would initially be very lonely, since only a tiny minority of people are interested in a given innovative project during its rough early phase. However, those who do manifest their interest in the beginning of a project and interact with others involved contribute by refining and improving it with their constructive criticisms, insights, and different approaches. Such peers may not exist at the local level; however on the global scale, finding people with similar interests and complementary skills is obviously more likely – but only if they can be effectively identified. Developing the tools to do so is not trivial, but should be possible by creating new platforms dedicated to creative project incubation and by studying the trails of academically relevant sites visited and computing their distance in the idea landscape. Combining *idea-mate* identification tools with geolocalization data and mobile technologies will enable two or more idea-mates to meet in person if they live near each other (people live in cities today, in close proximity to many others) or when they travel, since updated information on their positions could then be used to invite people with similar interests to visit them. Real campuses could serve to host such interactions, and public hubs dedicated to such meetings of persons

who share common projects could be set up in places that do not yet have campuses (many public learning spaces could be used for this purpose: science museums, libraries, science cafés, agoras, shared working spaces...). Such project incubators could constitute a network of learning spaces that would be an alternative to classical campuses for hosting and favoring new learners by providing them with the interaction and facilities they miss most when sitting alone in front of their computers. Learning has always taken place in varied settings and contexts, not only physical venues, such as schools and universities, but also in intangible form, such as during interactions with peers, parents, or the natural world, and in the digital age this truer than ever. Learners' brains have evolved in ways that enable them to see connections between different forms of learning; however this is not always successful, since it is sometimes hard to reconcile views that conflict or that seem to subscribe to a different world outlook. Developing tools to favor these connections and optimize what is best learned in formal or informal settings should therefore be a priority for further investigation.

Knowledge-builder perspectives on the future of learning

The digital world will provide many new opportunities for formal and informal learning during the 21st century. The questions that we will have to address in the future include:

-How can we optimally articulate these new opportunities with more classical ones?
-How can new tools help the learners of tomorrow more readily observe interactions among different pieces of information and recognize their relevance?
-How can experience and knowledge be recognized?
-How can information be tailored so that it is relevant to learners' questions? (The answer should neither ne too simple, hence boring, nor too arcane, hence discouraging.)
-How can we find the right people to question, with whom to discuss ideas, and who can conduct projects?
-How can one become a co-operative, creative knowledge-builder able to continually update existing knowledge and produce new knowledge?

The results of a major survey conducted by edge.org on how world-thinkers see the Internet ranged from that it changed thinking to that it changed nothing about the way brains work to that it changed everything we do. This may not be as paradoxical as it seems. Our brains have evolved over millions of years, and their basic architecture has obviously not been totally reshaped by the web. However, we do know that learning and reading utilize pre-existing modules in our brains that we are now using to automatically decode texts. Using digital technologies radically changes the way we obtain information, but may not have changed much of how the brain processes it. Considering the over-abundance of information of heterogeneous quality, critical thinking may be more necessary than ever before; however, Socratic questioning may be just as valid as ever. Knowledge gathered by experts in the fields of education, social science, and cognitive science can therefore be used to adapt the educational system to the challenges mentioned above. For instance, it has been shown that intrinsic motivation-driven learning is more efficient than extrinsic motivation based learning, in which students learn to pass exams and satisfy parents or teachers. Similarly, when curiosity and creativity are engaged, learners not only better memorize facts being discussed, but also acquire more skills, such as how to find, critically discuss, or synthesize information relevant for achieving projects. These skills are essential in a world in which everyone will need to learn how to learn throughout life.

Furthermore, project-based learning can help students learn to update knowledge when they need it, a skill that is likely to be useful in their personal and professional futures. Interestingly, education studies have also shown that these aptitudes that are so necessary in research work are also required for knowledge-building at all levels. Thus, children can learn in ways that are not so different from those used by researchers, since they learn by repeatedly experimenting on their surroundings. Knowledge used and generated during such activities can be encoded in a digital format that is readily retrieved. As a bonus, these digital portfolios will be constantly enriched, permitting assessment of each contribution and providing feedback in a much richer way than multiple-choice exams. Furthermore, with the author's consent, these digital archives can be made available to other knowledge-builders who can add onto it, critically analyzing what is available and keeping the part that is relevant for them to further their own knowledge.

Perspectives

In the future, all members of society should first learn how to learn and to update their knowledge throughout their lives. Learners of all ages anywhere on the planet should have access to resources that allow them to locate information relevant to their educational and professional needs, and be able to store, exchange, and discuss it with others who have similar interests. Everyone would thus be able to meet like-minded learners both online and in real life with whom to discuss ideas and develop new projects. In this somewhat utopian but at least partially attainable view, everyone can become a creative and collaborative knowledge-builder. An increasing number of countries have adopted similar goals to train their citizens to face the challenges of the 21st century. The changes described above started with smaller, locally developed steps, and bottom-up initiatives taken by students, educators, and scientists. Some universities and countries that are more prepared for such changes may encourage these efforts and develop top-down strategies to support these views and integrate them into a coherent whole, in which the co-operation of all higher education actors can benefit everyone. In the long run, by exploiting the logic of creative commons, in which everyone can benefit from a co-operative endeavor, such a model would improve and spread rapidly. Using the appropriate tools described above, locating relevant information and meeting like-minded, stimulating people with whom to interact would then be accessible to everyone, anywhere in the world, transforming the whole planet into a global campus linking knowledge builders, ideas, and learning spaces. Combining increasingly better real-life and digital interactions is a very challenging goal, but it is probably necessary for the future of education. It can also allow everyone to participate in building our joint future. Being able to optimally harness the collective power of human brains and the Internet is crucial for research and for the future of our knowledge-driven societies. Universities X.0, building on centuries of expertise and constantly updating their practices, situated at the leading edge of such challenges, would enable us all to construct our common future on our resource-limited planet.