Do Web 4.0 and Industry 4.0 Imply Education X.0?

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What is the education scenario emerging on a five-year horizon, if we look through technological and labor-market lenses? How high an impact do technical achievements have on the organization of schools and universities? Who is going to take responsibility for required changes that are recognized worldwide as unavoidable? How does education cope with the incipient challenges exposed by enterprises that are about to face Industry 4.0 reorganization?

Here, we answer these fundamental questions, providing insight into the comprehensive strategies assumed by a broad and complementary partnership that—though established in one region—involves all governing bodies that can sustain the education process required to scale from a local to a global scenario.

Education Profiles

A direct relationship exists between the web's evolution and the corresponding education profiles—technological changes make new services available—thus triggering new contexts in which interaction models for education can arise more efficiently.[1] In this way, Web 2.0 enabled its learning profile, as happened with Web 3.0. Something similar will occur again soon, when Web 4.0 offers new opportunities resulting from a deeper symbiotic interaction between man and machine, including emotional exchanges between them. Though relevant, this scenario has far to go before it can be achieved on a large scale. Hence, the Education 4.0 profile has barely dawned on the stage of real life. Today's state-of-the-art technology indicates that Education 3.0 is a reasonable current scenario for education, combined with sustainable learning paradigms.

The timescale we can trace for the web works well as a common denominator for both education and industry contexts (see the "Web, Industry, and Education Timescale" sidebar). In fact, the story told for Industry 4.0 will require at least all those technologies made available by the Web 3.0 domain.

Table 1 describes the education profiles for Education 1.0–4.0, adopting an attribute-based framework (*teacher* through *means*) to get comparable patterns. Looking at the Attribute column in the table with labor-market needs in mind, any education profile can be suitably shaped to cope with this market's requirements.

In the case of Education 3.0, the *student* attribute emphasizes a more active role played by learners. As Table 1 reports, learners are in fact recognized as creators of knowledge artifacts who hold appropriate competencies. They engage across a wider cross-institutional and cross-cultural context, enabled through sharing opportunities afforded by social networking. Likewise, the Education 3.0 *learning process* and *learning organization* attributes describe the impact of learning when it is no longer bounded by the stable environment of a traditional classroom. The entire organizational system is under pressure because time and space are no longer independent, and learning domains—once detached

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Web, Industry, and Education Timescale

After the establishment of the technology framework used to develop the network, beginning in 1991, Web 1.0 refers to a static functionality provided by the Internet, often defined by experts as the "read-only" web.[1]

Web 2.0 has flourished since 1999, when the read-write era—mirroring the producer-consumer paradigm—arose, and even nontechnical users started contributing to the web's growth through emerging blog platforms.[2] A further jump was Web 3.0,[3] which—by extending Tim Berners-Lee's definition—around 2007 became a "read-write-execute" web, in which "execute" includes web services and semantic mark-up.[4]

Web 4.0, a "read-write-execution-concurrency" scheme, is now emerging from the fog as an open linked web framework,[5] shaped like a cloud, encircling users and machines in a symbiotic interaction.

We can sketch the same historical picture of the industrial domain: Industry 1.0, at the end of the 18th century, is often referred to as the mechanization cycle, mainly characterized by the steam engine. Indeed, Industry 2.0 signals the second industrial revolution, placed at the beginning of the 20th century and often referred to as the electrification cycle. Industry 3.0 came 60 years later, exploiting the invention of both the microprocessor and the programmable logic controller, which introduced the computing power suited to shape automation and bring it into plants on a large scale.

Today, Industry 4.0—the "New Industrial Revolution"—focuses on cyber-physical systems, in which machines communicate efficiently with each other and with their users;[6] it features real-time responsiveness even for cloud-based control systems.[7]

Within the education domain, Education 1.0 came about by merging essentialism, behaviorism, and instructivism.[8] It inspired Web 1.0 and its one-way transfer of knowledge: the teacher is, in fact, the sole knowledge producer according to the "teacher-centered" model.

Education 2.0 evolved when Web 2.0 became solid ground on which traditional approaches to education could improve via podcasts, blogs, social bookmarking, and similar collaborative technologies. The role of communication technologies is emerging with just as much intensity for Education 3.0, the era we are in today.

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from each other—become one domain, in which the borders among processes, people, and products remain blurred.

Hence, with Education 3.0, rules, policies, strategies, and even facilities and arrangements must change perspective, providing opportunities for new, emerging learning approaches. Such approaches also alter the way in which disciplines evolve within the learning process.[2] Nevertheless, the primary focus is on the student, who might in turn become a producer of reusable learning content.

At this point, relevance should also be given to regulations and licenses—complemented by suitable accreditation processes to certify any producers for the competencies they've achieved—which sustain creation, exchange, and sharing of further work derived from already existing work. In fact, relevant features for new staffing requirements now focus on the learning pace and aptitude students have for self-organizing core content in particular fields—even technological—and mastering an enormous amount and variety of information.[3]

Therefore, real-world examples currently suggest that most relevant skills and competencies should be those that can withstand continuous and progressive self-upgrades and self-tuning, and are transferrable and directly applicable across various social, business, and professional settings.

This scenario suggests 21st-century skills or lifelong learning competencies, including knowledge construction; adaptability; the ability to find, organize, and retrieve information; management; critical thinking; and teamwork.

Following this line, the labor market identifies critical skills as those required to enhance performance on the job site, where communication, teamwork, problem-solving, self-management, planning and organizing, technology management, life-long learning, and entrepreneurship competencies take over. Hence, such critical skills help

Table 1. Education profiles.

Attribute	Education 1.0	Education 2.0	Education 3.0	Education 4.0 (*still emerging*)
Teacher	Knowledge source	+ Counselor, guide	+ Leader of collaborative knowledge creation	*+ Supported by an AI-based learning portal*
Content delivery	Traditional copyright support	+ Free/OER* (inside disciplines)	+ OER created and used by the learner; delivered across disciplines, institutions, certified sources (MERLOT, Coursera)	*+ Available in AI-based learning portals integrating certified OER with individual adaptive learning*
Learning process	Lectures, essays, assignments, written and oral tests, bounded group work	+ More open technologies (such as Arduino); learning by project; confined to institution and classroom boundaries	+ Open learning activities addressing student creativity; social networking outside boundaries of discipline, institution, and nation	*+ Adaptive learning driven by the AI portal tuning the learning process according to real-time learner profiles*
Learning organization	Buildings with fixed boundaries among co-located institutions; teaching, assessment, and accreditation by a single institution	+ Collaboration among institutions (ERASMUS, EU student exchange); still 1-to-1 affiliation between learner and institution	+ Teachers exchange, one-to-many affiliation between learners and institutions (for example, double degree)	*+ Institutional affiliations irrelevant; new institutions providing AI-driven high/higher education on Internet; breakdown of national, regional, and institutional boundaries*
Student	Mainly passive	+ Evidence of transition to an active profile; enhanced ownership of own education process	+ Ownership of own education plan, co-develops new ideas and artifacts	*+ Autonomous; counselors and AI help co-develop education plans, continuously updated by adaptive mechanisms*
Means	E-learning management system, but limited to a single institution	+ E-learning collaborations involving other institutions, mainly within the borders of a single learning management system	+ Web-driven technologies to address full individual distributed learning environments consisting of a portfolio of applications (for example, MOODLE)	*Web-driven e-learning organizations integrated with several AI applications*

*OER: open educational resources

people to cope with changes and improve their career opportunities.

A Modular Design for an Education 3.0 Architecture

In December 2016, Italy's Compagnia di San Paolo Foundation—through actions put in place by the Foundation for School—launched the Re-Connections in Progress (RCP) initiative (www.fondazionescuola.it/riconnessioni-corso). This project proposes an Education 3.0 framework that can scale at both the regional and national levels. It enforces results achieved in practice and via experimental projects[4–6] undertaken from 2012 through today, with support from the Ministry of Education, Universities, and Research.

RCP aims to offer all schools in the city of Torino—including nearby neighborhoods in which two Alpine valleys widen the planned geographical map—the ability to exploit opportunities arising from the widespread use of Education 3.0.

Although the two lower layers in the project plan architecture host the development of an interconnection infrastructure (geographical and internal), thus expanding Internet access, a question arises as to whether technology is the proper, even partial answer to the digital delay demonstrated in the education domain. The answer is given in the *Survey of Schools*,[7] which reports on the number of students per computer and the percentage of students unable to get access to

the Internet. These data indicate the high relevance of appropriate network infrastructures and denounce the still-slow adoption rates of some European countries.

The two higher layers in the project architecture host organization functions and learning processes, respectively. In fact, the recent acceleration in new technology development has made ubiquitous access and learning material processing possible. Also, methods of delivery and use are more efficient, improving personalization and security for the whole education process. Inspiring examples are the Codecademy (codecademy.com) and, with a broader range, Khan Academy (khanacademy.org) educational models, which provide both personalized learning to any student (including accurate assessments) and dashboards to teachers. Various Internet portals provide myriad learning experiences, and some also propose adaptive learning as a stable method even for tracing learners' profiles.[3]

Another opportunity to play at those higher layers of the architecture is the enormous Internet acceleration as demonstrated through social and industrial automation. This derives from the explosive growth of digital devices such as video cameras, RFID readers, tablets, cards, and tickets, which, coupled with Semantic Web and federated web services, together improve the quality, efficiency, and security of any process in operation. It is becoming easier to connect machines, things (whatever they may be), and even classrooms and application processes to the Internet and to each other. In this context, the bring your own device (BYOD) movement has a relevant role, given that a growing number of students, all with their own devices, enter into classrooms and connect to institutional networks.

On this basis of stable interconnection power, learning analytics—as a web application headed toward learner profiling—has a highly disruptive impact. It analyzes the properties and behavior of individual students whenever they interact in online learning tasks. At any time, the changing dynamic of the learner's profile is relevant, and adaptive learning takes place by adjusting how the profile affects the student's needs. Adaptive learning stems from a sophisticated, data-driven, nonlinear approach that can shape the learning process according to a learner's interactions and assessed performance targets by identifying the types of content and resources that a learner needs at a particular point in time.

Landmark efforts carried out in Europe over the years show that merely introducing digital technology into the classroom is not enough to overcome the drawbacks traditionally identified by education stakeholders. Business, education, and government, together with emerging social trends, are increasingly demanding connected learning, thus leading to a new, widespread response concerning new learning paradigms both inside the classroom and at home.

RCP shows that the current emerging education framework must encompass the complex relationship network among all stakeholders, including students, parents, teachers, schools and universities, enterprises, and governing bodies, as well as the solution providers who set up various parts of the entire ecosystem. The main aim in this context is improving the efficacy of the education process to make learning sustainable for any learner independent of his or her culture and age.

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