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Big Data, Cognitive Computing, and the Future of Learning Management Systems

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Introduction

Both technology and society are living a continuous evolution process, driving innovation and the development of novel solutions in almost any field of application. Making reference to the specific scenario of Technology Enhanced Learning (TEL), we observe significant steps ahead in techniques and methodology and, consequently, technological solutions undergo a continuous upgrade to cope with these, to the aim of improving the quality of services, the usability, the overall performances, the effectiveness of education, and to provide a more pervasive experience for learners. Accordingly, e-learning environments and the related tools have been growing in complexity (Bouquet & Molinari, 2016) i.e., from Learning Management Systems (LMS) based on a centralized software architecture toward clusters of Massive Open Online Courses (MOOCs) platforms in cloud-based distributed architectures. The importance of technology as a driver for the future of education is recognized in prior studies (e.g., Schuck, Aubusson, Burden, & Brindley, 2018), and TEL seems also to absorb the general current trends in IT, specifically disruptive technologies

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that include ubiquitous and pervasive computing: Learning Analytics, Big Data, and Mixed Realities.

Many things are dramatically evolving, with contaminations coming from different sectors, most of them are mainly owing to the rise of big data and cloud computing. In this line, we believe that one of the most promising directions to be explored in TEL is related to the adoption of cognitive computing solutions (Coccoli, Maresca, & Stanganelli, 2016). These complex set of approaches and technologies is an enabler for a number of new functionalities. Moreover, the introduction of the cognitive computing paradigm also impacts on the learning process, as schools and universities must face with new jobs and new training demands, where big data contexts are fundamental, since new knowledge and skills should be delivered at a speed never seen before (Coccoli, Maresca, & Stanganelli, 2017). In this paper, we will present our vision about the adoption of cognitive computing inside TEL, depicting the impact on new platforms and services for the future of this discipline.

The paper is organized as follows. Section "Related Works" reviews related works to outline the current situation and guess trends for LMSs. Section "From Classroom to Communities" considers the users' perspective of cognitive computing and investigates the process that is transforming classrooms in communities. Section "Next Generation TEL Platform" highlights what we consider as mandatory characteristics of TEL platforms. Section "The Italian Cognitive Computing Community" reports the inherent activity that is carried on by a group of Italian researchers within the newborn Italian Cognitive Computing Community (ICCC).[1]

Related Works

The possibility of gathering big data from a wide number of heterogeneous sources, combined with the unprecedented opportunities of exploiting such data with cognitive computing techniques, is reshaping the technological scenario of many fields of applications. E-learning is overwhelmed by such a sudden change, which allows improving existing methodologies as well as imagining new ones. In this respect, modern LMSs are evolving and they offer new functionalities so that many researchers are investigating this trend. In the following, we report briefly a variety of works focussing on e-learning systems and related services, based on the exploitation of big data through artificial intelligence and cognitive computing techniques (Coccoli et al., 2016). From a quick analysis of the relevant literature, a lot of scientific work is related to learning analytics. Recording, storing, and aggregating information is a fundamental tool for improving feedback to students and improvements of educational paths (Fedrizzi & Molinari, 2013), big data analytics must be done within the LMS, to the aim of improving learning performances of both students and teachers.

Banica and Radulescu (2015) analyze the impact of big data on education focussing their attention on the academic environment, which has a large scope

[1] http://it-cogcom.com.

and some specific peculiarities. Their expectation is a change in the way e-learning is approached by students and teachers. Based on the currently available software solutions, they propose a system architecture for a consortium of universities to analyze, organize, and access huge data sets in a cloud-based environment. Exploring the large amount of data available on the Web, e.g., online communities, messaging services, social network sites, social media, Dietz-Uhler and Hurn (2013) showcase learning analytics techniques allowing to derive knowledge from large blobs of information. Specifically, in their work they focus on tracking students' data, to help them succeed. They survey learning analytics tools adopted in different universities and institutions and how faculty can make use of data in their courses to monitor and predict students' performance.

Following the same current, Yu and Jo (2014) also show an example of how to fruitfully exploit big data for the prediction of the students' performances, to the aim of optimizing their careers. Moreover, Kolekar, Pai, and Pai (2017) are observing the large amount of information freely available over the Web investigating the opportunity of using such data to get enhancements in all the phases of the learning process. It is pointed out that social media play a vital role with respect to e-learning system (Colazzo, Molinari, & Villa, 2009) and the effective use of information totally lies with the way we utilize these data. In this respect, also Sheshasaayee and Malathi (2017) believe that the application of big data with e-learning is a hot topic, which has the potential for creating a huge impact on the whole education system. All of these can provide useful hints on how to reshape existing LMSs.

Besides, from the methodology perspective, Cen, Ruta, and Ng (2015) introduce the idea of "big education" applying the paradigm of big data to the whole education process to predict students' performances, based on individuals' learning attitudes and their after-school activities. This seems a promising vein, since also Gudivad (2017) theorizes about cognitive analytics-driven personalized learning, which can be achieved owing to the advances in cognitive computing for analyzing unstructured data, e.g., blogs, discussions, e-mail, and course messages, to gain insights into student learning at an individual level.

New functionalities are tied to new technologies, like, for example, the mix of learning and semantic technologies through the use of ontologies for the description of the domain(s) (Bouquet & Molinari, 2012), and, in this specific case, the availability of sophisticated cloud infrastructures is required to handle properly such a huge quantity of information, as well as the design and development of new learning environments, supporting suited machine learning technologies. We observe that when considering big-data-capable learning applications, a paramount item emerges, i.e., the students' data protection. In fact, personal information in the e-learning frameworks can be very detailed, thus very precise profiling can be obtained and maliciously used for different scopes, such as remarketing. This topic was faced by Habegger et al. (2014), which clearly present possible threats of considering big data within e-learning platforms, as well as privacy and security cannot be neglected (Caviglione & Coccoli, 2018).

From Classroom to Communities

E-learning has become a very competitive world, with a lot of public and private Institutions that provide a lot of possibilities for our professional growth. From personal to professional needs, from private sector to public administrations (Casagranda, Colazzo, Molinari, Tomasini, & Villa, 2011), the perspective of lifelong learning is our present and our future, and the formal education activities should expand their boundaries also involving industries and the labor market (Colazzo, Molinari, & Villa, 2011). In this perspective, defining the location where the education processes take places as a “classroom” (whether real or virtual) is limiting the perspective of what today a smart education could and should be. This requires a paradigm shift to transform classrooms into organized virtual places where people use educational tools and services, where we can speak of men *and* machines, rather than men *or* machines, to empower humans’ transformation of their skills.

This virtual place where education can take place, in a physical room or through a mobile device, together with people that you regularly meet or together with people that you will never meet in person is a “virtual community”. This (virtual) place, so important for our present and future learning processes, should condition in our opinion not only the educational processes, but also the way software platforms should be built. Many years ago we started to follow this new approach to education through “Online Communities” (OLC), a collaborative environment totally designed and developed without referring to any existing LMS paradigm or software architecture.

Starting since 1998, when neither Facebook nor Moodle or Sakay were even existing, we decided to develop from scratch a virtual community platform called “Online Communities”, as an alternative to proprietary platforms like WebCT™ or Blackboard™. The decision to create this platform was a consequence of various reasons: principally, the use of commercial software would have been possible at too high a cost (acquisition, maintenance, management and training) when compared to budget limits. This is the same reason why so many small–medium educational institutions (like high schools) are using Moodle without even understanding the impact of it on their educational processes: uniformity, flattening of services, complexity in connecting the LMS with the rest of the organization’s information system (Colazzo et al., 2009).

Many administrators of the information system, especially in the educational sector, are adapting their needs to the software system that, somehow, is able to solve most of their problems, and they mostly are resistant if not reluctant to develop an internal solution. Money, availability of qualified resources, short time to implement the solution, these all are comprehensible reasons for choosing the easy way of acquiring a pre-cooked solution.

To support those trainers willing to experience the use of computer technologies in their educational processes, we developed a completely new platform that moved from a mere LMS to a more structured set of services that support collaboration among members of the virtual community. Organizing educational tasks inside a "classroom" or "my courses" metaphor (what you find behind the LMS available today) means forcing stakeholders of educational processes to adapt much more complex processes to what the platform provides. They normally "adapt" themselves to what the platform supplies out-of-the-box, thus limiting the innovation potential of their ideas, and forcing users to adapt their learning processes to the technological tool.

Collaboration processes are those that mainly suffer this limitation: the idea of (virtual) community allows to extend the usage of the platform to any other environment where collaboration among participants to the community are mediated by ICT (Kimball, 2002). This personalized software is able to supply better and personalized services that ease procedures and processes for the different users (students, professors, administrative personnel). Social media, like Facebook, Twitter, Whatsapp, Instagram or similar media are great tools when applied to the context they have been originally created, mostly exchanging multimedia information among peers. Yet, it is not so easy to integrate them in the educational processes, not only because of technical availability of integration mechanisms and privacy issues, but also because of an educational design problem. How do we cope the style of the lecture with the usage of social media made by our learners? How is changing the role of the teacher and what are the expectations of learners about the use of social media? How do we differentiate the use of social media respect to the target? Using these tools in academic teaching is different respect to their usage in professional business environments.

Probably, we need adaptive technologies that understand context, usage of language, expectations and background of learners, and adapt from the interaction style to the material provided, from the pace of the lectures to the interaction with trainers. This is a typical application of cognitive computing, where the system "understands" the learner interaction profile and adapts itself to this. Posting a photo or retweeting others' comments is a very beneficial aspect for training, especially professional training, but educational processes are more than this. Sometimes, educational processes need the support of other tools and services, that social media can provide through a distorted usage of its services, because they are *not* educational services. The usage of social media in education therefore forces educators to adapt their learning processes to what the platform provides, while it should be exactly the opposite, i.e., the platform should adapt services to users' needs. Last but not the least, the capabilities of expanding social media services to educational needs are simply driven by economic consideration, not necessarily coinciding with educational needs. It is sure that cognitive computing will impact every decision in the following decade, but education seems to be not on the radar of social media.

The innovative aspect that we introduced with "Online Communities," and that now constitutes an extra advantage, is to construct the services considered relevant by educational experts, based on the precise educational needs of the different users: teachers, students, or any other role involved. If we consider cognitive computing and the power provided (and needed) by cognitive computing platform, the idea of using (micro) services provided by external suppliers, and consuming them according to the specific needs is a good starting point for our research. These are very important architectural aspects for our argumentation about a next generation of TEL platforms:

(i) We entirely wrote every line of code of the platform, so we do not depend on different contributors (like in many open source projects) and we do not suffer the "will the new release cover my customization?" syndrome;
(ii) The platform is based on a micro-service architecture, allowing to be easily extended in any direction;
(iii) We added a semantic-enabled extension of the persistence of the platform, i.e., some parts of the platform can be stored as a semantic representation of the knowledge in RDF triples (Bouquet & Molinari, 2016). The triple (or quadruple) format for persisting (part of) data relevant for decision-making and cognitive computing is another component that is not currently available in mainstream LMSs, and that is native into "Online Communities."
(iv) We have also integrated some soft computing, fuzzy logic-based decision support systems (Fedrizzi & Molinari, 2013), to support decision-makers with intelligent tools about educational processes;
(v) The platform is natively equipped with a new storage layer collecting data from all services available in the platform: this big-data-enabled extension of the platform is particularly useful for our cognitive extensions.

Next Generation TEL Platform

According to the above considerations, we consider that as a foundational element for new services in TEL the existence of a new generation of TEL platforms, which must be re-designed respect to the approaches that have been used in the past decade to create most of the current LMS. These new architectures must keep into account the definition, design, and use of novel cognitive services, where big data about training and learning are acquired and historicized, on top of which we foresee the application of a new set of cognitive services that could improve.

(a) The learning processes, providing the users with a much richer set of services personalized for the respective needs;
(b) The teaching processes, providing new suggestions about the best material for the individuals, finally aiming at a "personalized education" that consider what the learner is, what she wants, what is better suited for her needs;
(c) The administrative awareness of how learning processes are conducted, controlling time and kind of resources used, and imagining new business models related to intelligent usage of educational resources;
(d) The decision support processes for the educational institution's decision-makers, which can use cognitive services to intercept trends and formal/informal needs found by cognitive services into the amount of analytical data collected, on forum posts, on teacher–students interactions, etc.

In order to foresee these different scenarios, the fundamental factor of next generation TEL platforms is the presence of cognitive services pervasively integrated inside the core architecture of the system. Here we have two sides of the word "learning": learners that will increase their knowledge, thanks to educational processes; and machines/systems/platforms that will learn about learning processes, thanks to the use of cognitive services. However, thinking that a cognitive service is only the result of an algorithm is a wrong starting point: it is something more because learning does not "come only" from a software algorithm but it is also due to a very complex hardware architecture that implements it. A cognitive algorithm is performed on a parallel architecture and the latter must be dimensioned according to the learning needs of the algorithm itself. In other words, since the algorithm must be trained, we often need substantial memory and computational resources to be implied in educational processes characterized by the cognitive approach.

Precisely for this reason, the personalization of cognitive services will require additional hardware and software resources to be sized to achieve the objectives.

For this reason, when defining a cognitive TEL we have to go beyond a basic hardware machine because personalization will require a system to adapt over time to the use we will make of it, in the perspective of a lifelong learning support to our knowledge growth. This capability is offered by the cloud, from Platform as a Service (PaaS) hardware machines, and from Software as a Service (SaaS) solutions. Furthermore, feedback is needed to improve the effectiveness of this approach, and so we should be able to observe the system by measuring it and updating it in real time. Clearly, these platforms provide to LMS the computational power needed for computing services, but at the same time these computing platforms are not created specifically to supply the whole set of services that a virtual community platform can provide to its users.

These considerations push to build innovative architectures for the platforms that must provide an educational environment whose particularity is to be able to change configuration quickly in order to adapt to the different needs of learners and teachers. In particular, the authors thought that a wise adoption of the best of some services from multiple vendors, within the same platform, could improve the satisfaction of end-users as well as solve the structural problems of the laboratories. Often University laboratories need to be scalable on a different number of students, they need to be used for different educational activities (lessons, exercises, application laboratories, exams, etc.). Sometimes they must even be scaled up to more applicative situations, like some tests for research projects or experiments.

The authors believe that, in this case, an integrated environment is needed, and from our preliminary analysis and tests, Microsoft Azure and IBM Watson could coexist within the cloud in order to realize both the needed PaaS and the SaaS. Figure 1 shows an example of the Azure environment in which the sizing of the hardware machine is offered for the different cases of (i) courses, (ii) laboratories, and (iii) exams.

The common dashboard for the teacher and the student offers the possibility to instantiate a laboratory session or to take part in an exam session. The only requirement is the availability of a PC and a possibly fast connection.

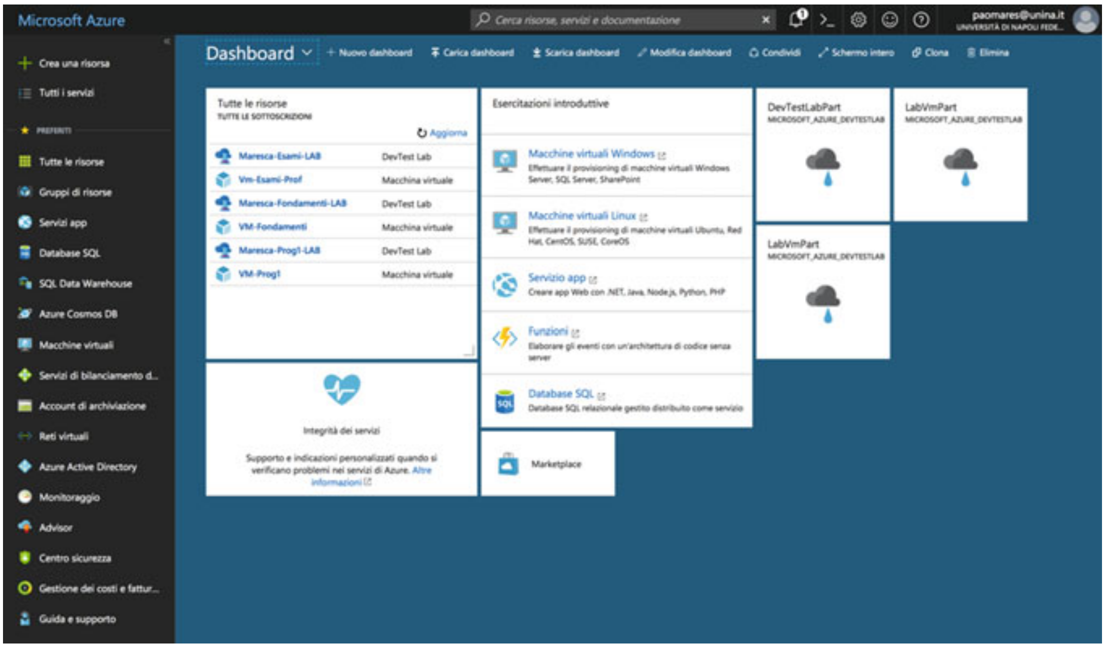


Fig. 1 The Azure dashboard

For example, the teacher can, in a laboratory consisting solely of the PCs that students bring with them, instantiate an exam session on the fly as shown in Fig. 2.

The student after having profiled with his institutional credentials visualizes a dashboard and chooses his activity: laboratory, exams, etc. In the specific case, the student takes an exam but in the same classroom can coexist with students who are doing different activities. For example (Fig. 3), the student is logged into Eclipse where he can decide whether to compile a program or enter the IBM cloud, through the appropriate plug-in, and also use Watson's cognitive services.

At the end of the activities, we can ask students to provide their opinion on the environments used. In particular, students were asked to provide overall feedback on satisfaction and usability. The information gathered, on a random sample of about 50 people, about the overall satisfaction of the platform, are shown in Fig. 4.

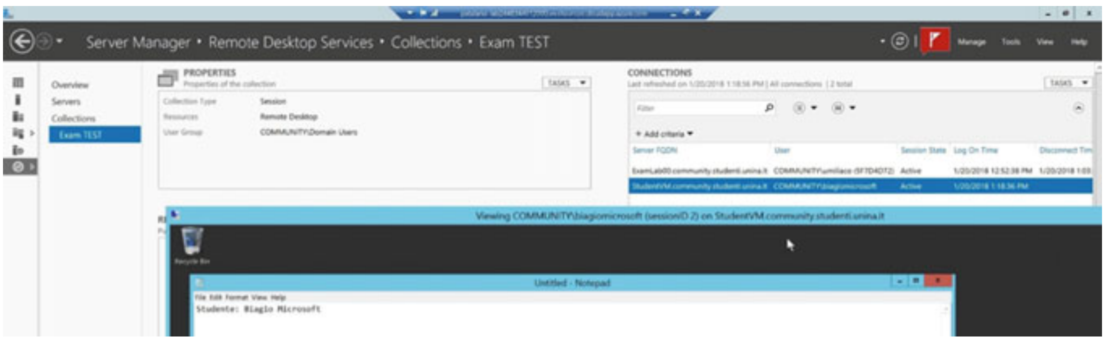


Fig. 2 The Azure server manager

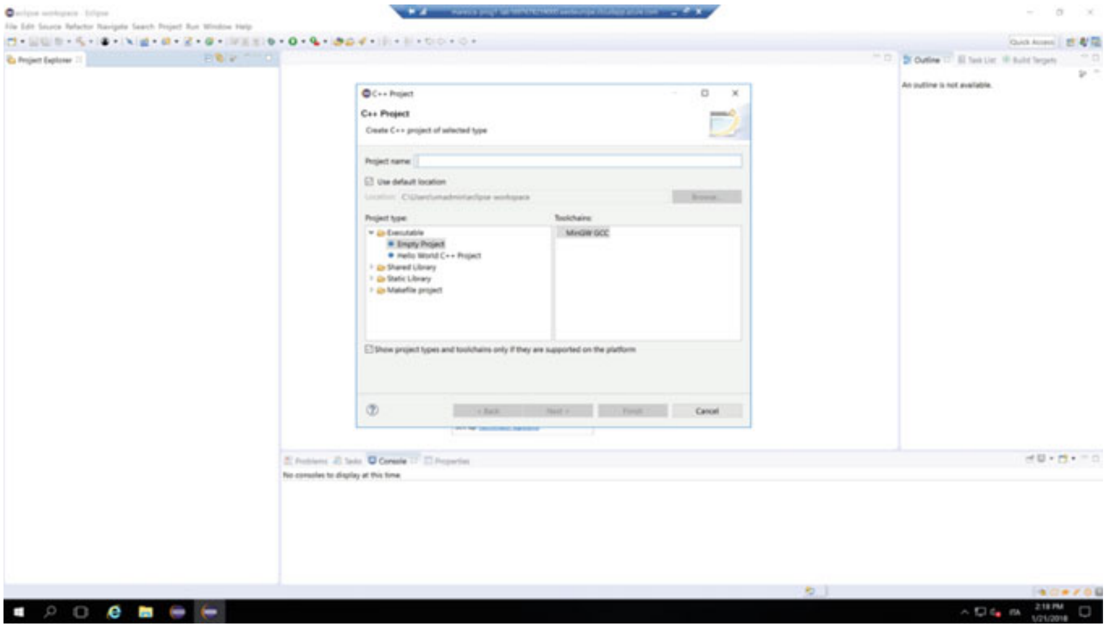
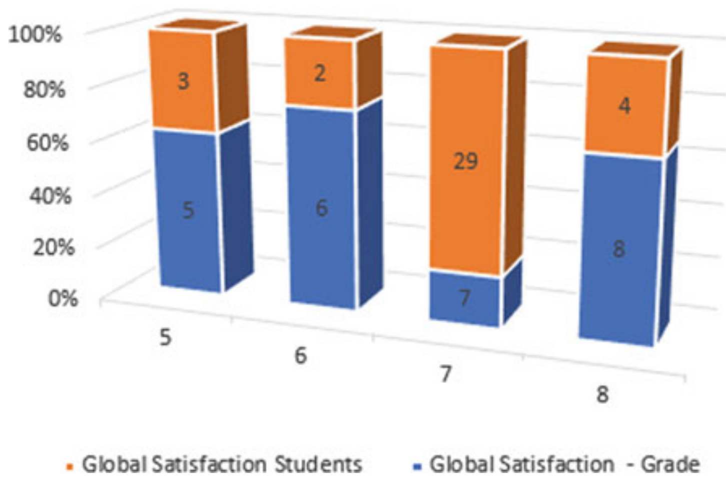


Fig. 3 The eclipse environment used by the Azure SM

Fig. 4 Satisfaction of use for TEL



Since these integrated environments of multiple technologies may be too complex for young students, we have also asked to comment about usability and this is what we have collected (Fig. 5).

It is evident that not only the presence of two different environments but also of concepts that synthesize the existence of functionality often put the students in difficulty. This is the expression of the judgment that they provide to usability which, however, results in an ordinal scale from 5 to 9, quite positive despite the evident complexity. We therefore believe that a common platform, based on a more general metaphor than a classroom, about to provide conventional and non-conventional educational services as a uniform learning environment, is the direction we should move in the next years.

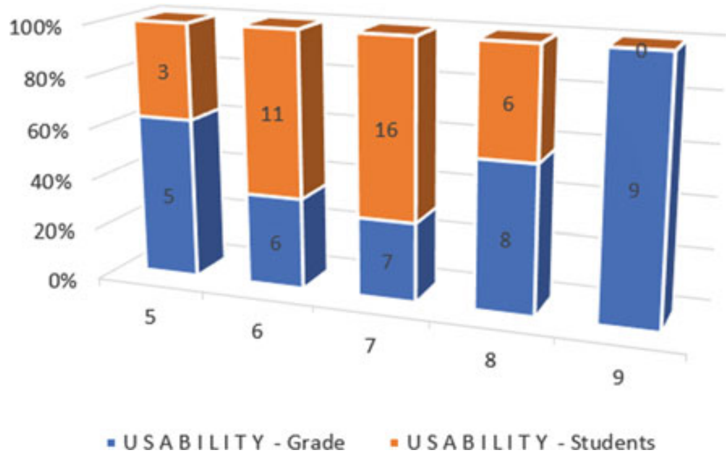


Fig. 5 Usability for TEL

The Italian Cognitive Computing Community

Another component of this vision of cognitive-enabled TEL is the support of the research community in the field of cognitive sciences. In this section, we introduce the idea of being supported by the newborn Italian Cognitive Computing Community, where a big-data-enabled architecture and some prototypes of cognitive services are under experimentation. The idea is to bring this innovation and new services into the architecture of the building cognitive TEL platform.

On May 18, 2018 the Italian Cognitive Computing Community was launched in a public event hosted by the University of Naples, Federico II. After this first step, 4 universities, 16 companies, the Accademia Aeronautica of Pozzuoli, 1 high school joined our community whose goal is to promote the use of cognitive computing technologies and accelerate the relevant research. In addition, the Community will try to become the reference point and contact point in Italy for all professionals, scholars, and researchers within the cognitive computing theme.

In short, the planned activities are the following: (i) set up a users' interest group; (ii) share and exchange experiences and information to grow continuously; (iii) create contacts and relationships between University research, the labor market, and the business world; (iv) publish research and disseminate in international conferences; and (v) support and organize initiatives for the promotion and dissemination of the group activities.

The main actors of this community will be companies, professional organizations and professionals, teachers, researchers, and students. We will pay particular attention to our students who will be among the main actors of this community and collaborate in establishing direct links with the industry. In fact, they are at a crucial turning point in which technologies such as the cognitive computing will completely transform the world of work and will be the key to the emergence of new professions. It will be interesting to think also to define fast and agile methods to update their curriculums in order to make them always current and relevant to the demands of the advanced industry world.

Based on a preliminary poll among the participants, we have identified the following topics of interest: (i) ethics in artificial intelligence; (ii) the use of cognitive technologies in e-health; (iii) the adoption of cognitive computing solutions in the agri-food chain, including the block-chain technology; (iv) the application of cognitive systems in pollution prevention; (v) e-learning; (vi) e-economy; and (vii) social issues. It is worthwhile noticing that people involved in the ICCC are from different areas, i.e., informatics, engineering, economics, robotics, medicine. For the e-learning topics, focus will be concentrated in the application of cognitive scientific advancement in the construction of a new cognitive-enabled TEL.

Conclusions

We are on a turning point of training processes, a very challenging and important moment in which cognitive approaches will transform most parts of our lives. Beside professional applications and high level-specific software systems, we are already experimenting a set of cognitive computing services in everyday activities, for example, using interfaces and assistants like chatbots, where to build, connect, deploy, and manage intelligent bots to interact naturally with the various users of educational environments. In practice, more often than we think, we are interacting with machineries that apply sophisticated decision-making process with very low time constraints and high accuracy.

E-learning is one of the fields of application that can mostly benefit from this, due to its complexity and to the variety of disciplines that must be adopted concurrently to achieve good learning outcomes. Especially, the use of big data strongly empowers the process of personalization and individualization of the learning processes. Moreover, e-learning is also called to provide suited solutions to the problem of learning such new technologies, which cannot be done in environments designed for different purposes. This raises the problem of developing a new generation of TEL platforms. The paper introduces the vision of the authors, where a self-made, highly customizable virtual community platform will be integrated with scalable, top-notch cloud platforms and congruent cognitive algorithms applied to the different parts of learning processes, from material selection to educational path suggestions, from peer evaluation to big data discovery for decision-makers. The process is still in its infancy, mostly because these three worlds (TEL platforms, Cloud services, and cognitive computing) are still separated and mostly focus on their own scope. What we are trying to do is merge the three disciplines/areas into one single research area, with precise objectives and deliverables, thus allowing e-learning to maximize the advantages of the fusion of the three. The paper presented some early ideas where to work on, and quickly summarize the role of the Italian Cognitive Computing association as a driver of innovation, collector of chances, and stimulator of new researches.

References

Banica, L., & Radulescu, M. (2015). Using big data in the academic environment. *Procedia Economics and Finance, 33,* 277–286.

Bouquet, P., & Molinari, A. (2012). Semantic technologies and e-learning: Towards an entity-centric approach for learning management systems. *Journal of E-Learning and Knowledge Society, 8*(2), 65–84.

Bouquet, P., & Molinari, A. (2016). A new approach to the use of semantic technologies in e-Learning platforms. *International Journal of Advanced Corporate Learning (IJAC), 9*(2), 5–12.

Casagranda, M., Colazzo, L., Molinari, A., Tomasini, S., & Villa, N. (2011). *Lifelong learning implementations in virtual communities: Formal and informal approaches and their impact on learners*. Paper presented at the 2011 IEEE Global Engineering Education Conference (EDUCON 2011) (pp. 1061–1068). https://doi.org/10.1109/educon.2011.5773279.

Caviglione, L., & Coccoli, M. (2018). Smart e-learning systems with big data. *International Journal of Electronics and Telecommunications, 64*(4), 445–450.

Cen, L., Ruta, D., Ng, J. (2015). Big education: opportunities for big data analytics. In *Proceedings of the IEEE International Conference on Digital Signal Processing* (pp. 502–506). Singapore.

Coccoli, M., Maresca, P., & Stanganelli, L. (2016). Cognitive computing in education. *Journal of e-Learning and Knowledge Society, 12*(2), 55–69.

Coccoli, M., Maresca, P., & Stanganelli, L. (2017). The role of big data and cognitive computing in the learning process. *Journal of Visual Languages & Computing, 38,* 97–103.

Colazzo, L., Molinari, A., Villa, N. (2011). Formal and informal lifelong learning in a virtual communities Platform. In X. Luo, Y. Cao, B. Yang, J. Liu, & F. Ye (Eds.), *New Horizons in Web-Based Learning—ICWL 2010 Workshops. ICWL 2010. Lecture Notes in Computer Science*, vol 6537. Berlin, Heidelberg: Springer. https://doi.org/10.1007/978-3-642-20539-2_31.

Colazzo, L., Molinari, A., & Villa, N. (2009). *Social networks, virtual communities and learning management systems: Towards an integrated environment*. Paper presented at and collected in the Proceedings of the 8th IASTED International Conference on Web-Based Education, WBE 2009 (pp. 209–215).

Dietz-Uhler, B., & Hurn, J. E. (2013). Using learning analytics to predict (and improve) student success: A faculty perspective. *Journal of Interactive Online Learning, 12*(1), 17–26.

Fedrizzi, M., & Molinari, A. (2013). A multi-expert fuzzy TOPSIS-based model for the evaluation of e-Learning paths. In *Proceedings of the 8th Conference of the European Society for Fuzzy Logic and Technology (EUSFLAT 2013)* (pp. 11–13). Milan, Italy.

Gudivad, V. N. (2017). Cognitive analytics driven personalized learning. *Educational Technology, 57*(1), 23–31.

Habegger, B., Hasan, O., Brunie, L., Bennani, N., Kosch, H., & Damiani, E. (2014). Personalization vs. privacy in big data analysis. *International Journal of Big Data, 2014*, 25–35. https://hal.archives-ouvertes.fr/hal-01270826.

Kimball, L. (2002). Managing distance learning: New challenges for faculty. In R. Hazemi & S. Hailes (Eds.), *The digital university—building a learning community* (pp. 27–40). London: Springer Science & Business Media.

Kolekar, S. V., Pai, R. M., & Pai, M. M. M. (2017). Prediction of learner's profile based on learning styles in adaptive e-learning system. *International Journal of Emerging Technologies in Learning, 12*(6), 31–51.

Schuck, S., Aubusson, P., Burden, K., Brindley, S. (2018). Current trends in technology-enhanced learning. In: *Uncertainty in teacher education futures* (pp. 43–61). Singapore: Springer.

Sheshasaayee, A., & Malathi, S. (2017). Impact and consequences of big data in e-learning. In *Proceedings of the 2017 International Conference on Innovative Mechanisms for Industry Applications (ICIMIA)* (pp. 726–729).

Yu, T., & Jo, I. H. (2014). Educational technology approach toward learning analytics: Relationship between student online behaviour and learning performance in higher education. In *Proceedings of the Fourth International Conference on Learning Analytics and Knowledge* (pp. 269–270). Indianapolis, IN, USA.