EDUCATION ON THE CLOUD: RESEARCHING STUDENT-CENTERED, CLOUD-BASED LEARNING PROSPECTS IN THE CONTEXT OF A EUROPEAN NETWORK

Hercules Panoutsopoulos[1], Karl Donert[2], Panos Papoutsis[1] and Ioannis Kotsanis[1]
[1]*Doukas School, 151 Mesogeion St., GR 15126, Maroussi, Attiki, Greece*
[2]*Innovative Learning Network Ltd. Blackwood Avenue, Liverpool L25, UK*

ABSTRACT

During the last few years, ongoing developments in the technological field of Cloud computing have initiated discourse on the potential of the Cloud to be systematically exploited in educational contexts. Research interest has been stimulated by a range of advantages of Cloud technologies (e.g. adaptability, flexibility, scalability, accessibility, cost effectiveness). For these reasons, there have already been efforts concerned with the educational uptake of the Cloud at different scale levels (mainly at the institutional and regional level). Apart from that, there are also larger-scale initiatives taking the form of research projects (e.g. the Rural School Cloud project). Nevertheless, most practices have been mainly shaped by the application of economic policies rather than systematic research. In this emerging situation, the aim of this paper is to present the activities of a European network, which has been set up to research how education should adapt and respond to advancements in Cloud computing. The innovative character of the network is that it attempts a holistic approach to the investigation of the effects of Cloud technologies on formal education by targeting at all involved stakeholders, and contexts of use, at all educational levels. By analytically presenting the adopted methodology and network members' vision for Cloud-based, student-centered learning and teaching, our aim is to provide a detailed account of the network's research activities.

KEYWORDS

Cloud computing, Cloud-based education, European network, student-centered learning.

1. INTRODUCTION

During the last few years rapid technological advancements have taken place with unprecedented effects on the ways in which people communicate and socialize, get informed, work, conduct their everyday exchanges, and, of course, learn. Technological developments and their impact on everyday lives and habits of people in general, and young people particularly, have major implications for decision-making and strategic planning on the quality and nature of educational services offered by formal education establishments. Personalization of learning is at the core of challenges that formal education faces with the focus being on supporting learners develop and carry out learning plans at their own pace. In this context, Saveri (2013) proposes the "*create-your-own-school*" movement as a future educational trend. With the use of this term, specific emphasis is posed on the need for schools to adapt to students' preferences, interests, and learning needs, as well as to their surroundings and particularities of communities in which they belong. Similarly, the NMC Horizon Report (Johnson et al, 2015) lists the broad adoption of a blended-learning approach, by higher education institutions, as a key, short-term challenge. In this way, educational organizations will be able to promote and facilitate instruction and learning beyond the confines of traditional classrooms and rigid time schedules, at each student's convenience. On the other hand, financial crisis has led to significant reductions in public expenditures on education. Despite the increasing demand for education and training, austerity puts significant limits in the funding of educational organizations, which have to "*do more with less in the coming years*" (OECD, 2013). Moreover, due to fast-paced technological changes, the need to maintain infrastructure and keep it up to date entails costs that may not be within an educational institution's budget (Sultan, 2010).

In this emerging landscape, Cloud computing promises to improve the efficiency of organizations and actors involved in education and optimize the technology-enhanced learning experience in an affordable way. Cloud computing is defined as "*a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g. networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interactions*" (Mell & Grance, 2011). According to the proposed definition, the Cloud is composed of "*five essential characteristics*" (namely, on-demand self-service, broad network access, resource pooling, rapid elasticity, and measured service), "*three service models*" (namely, Software as a Service – SaaS, Platform as a Service – PaaS, and Infrastructure as a Service - IaaS), and "*four deployment models*" (namely, private Cloud, community Cloud, public Cloud, and hybrid Cloud). Cloud technologies have the potential to improve the quality of provided educational services by allowing: (i) access to anything from anywhere in anytime on any device by anyone, (ii) sharing of knowledge that facilitates collaboration, (iii) remote interactions and monitoring of learners' progress, (iv) processing of large data sets through the availability of increased computational power, and (v) access to state-of-the-art tools and services without the need of purchasing and maintaining hardware or installing and updating software (Sultan, 2010).

Given all the above, the aim of this paper is to provide a detailed account of the activities of a European network, namely the School on the Cloud network (http://www.schoolonthecloud.eu/), which has been set up to investigate how formal education should adapt and respond to Cloud computing developments and whose activities are funded by the European Commission under the Lifelong Learning Programme (Information and Communication Technologies Action – Key Activity 3). More specifically, our intention is to focus on issues regarding the methodology through which network members research the potential of the Cloud to facilitate student-centered, personalized learning. To this end, after reviewing existing Cloud-based education efforts and initiatives, we proceed with the description of: (i) the network's structure and operation, (ii) findings of a survey among network members, and (iii) the context in which personalization of learning on the Cloud is envisioned.

2. EXISTING CLOUD-BASED EDUCATION PRACTICES

There are a number of Cloud-based education implementations and initiatives that have taken place in various contexts, and at different scale levels (Donert & Bonanou, 2014). Sultan (2010) provides accounts of Cloud-based solutions that have been embraced by educational organizations with higher education holding a greater proportion in Cloud use cases. For instance, the University of Westminster has turned to the adoption of a Cloud-based e-mailing service, because of the scarce use of the institutionally hosted e-mail system, as well as the provision of a suite of communication and productivity tools (namely instant messaging, shared calendar, word processor, spreadsheets and presentations applications) able to support collaborative learning activities. Budget requirements for the implementation of the recruited solution were low and consequently, provision of quality services in a cost effective way became feasible. Apart from that, another advantage of Cloud-based services is the availability of computational power for processing large data sets in an affordable way. This was the rationale behind the strategic decision of the Medical Center of Wisconsin Biotechnology and Bioengineering Center, in Milwaukee, to rent processing time on Cloud servers. As a result, analysis of research data became less expensive, whereas sets of raw experimental data along with results of conducted analyses become accessible to the wider research community.

Cloud-based education initiatives have also taken place in school education contexts. An indicative case is that of Kentucky's Pike County district, where Cloud computing solutions were adopted by its schools in an attempt to reduce public education expenditures. Among others, schools benefited from the transformation of a large number of old computers into fully functional virtual machines. With no need for purchasing and upgrading hardware, as well as keeping installed software up to date, available computers could be reused by receiving processing power and software from Cloud servers. As a result, teachers and students were able to become more productive by focusing on their tasks and activities without any concerns about infrastructure maintenance issues. Another example is that of Brescia House School (in South Africa) presented in the official website of Microsoft (https://customers.microsoft.com/Pages/CustomerStory.aspx?recid=300). By substituting the previously used LMS for a more usable and flexible platform, hosted by Microsoft, school

authorities managed to provide teachers and students with device-independent functionalities for accessing and sharing resources, e-mail services, personal storage spaces, as well as the potential to communicate and collaborate even through the use of social media. Apart from the above, there are large-scale efforts that have been concerned with the investigation of the Cloud's educational potential, such as the Rural School Cloud project (http://rsc-project.eu/). This project targets at the examination of methods of providing optimized IT solutions to schools that are located at rural areas, or away from cities, with heterogeneous populations. Based on EU-driven strategies that emphasize the importance of enabling schools with special needs (e.g. schools in rural areas) to access networked digital technologies, the Rural School Cloud project seeks to explore how Cloud technologies may offer learning solutions to highly diversified student populations.

All the above described cases of introducing Cloud-based technologies in formal education, or examining the educational potential of the Cloud, are different in terms of scale levels and incentives. Except for the Rural School Cloud project, most Cloud-based education initiatives have taken place with the aim to address issues faced at the local (e.g. institutional) level. Larger-scale implementations (e.g. at the regional level) have indeed been based on policies which, however, have been mainly formatted by economic reasons and not by systematic research. The innovative character of the School on the Cloud network's research is that it attempts a holistic approach to the investigation of the effects of Cloud computing technologies on formal education. By targeting at all involved stakeholders and contexts of use, as well as all levels of education, and by focusing on the individual learner, the network's intention is to raise awareness about potential benefits, provide guidelines and inform, and stimulate further research.

3. DESCRIPTION OF THE SCHOOL ON THE CLOUD NETWORK

3.1 Definition of the Research Problem

The School on the Cloud network targets at investigating how formal education should respond to fast-paced technological advancements and especially to the proliferation of Cloud technologies. More specifically, the intention is to narrow the existing divide between Cloud computing developments and their uptake by formal education establishments. To this end, the following two research questions are attempted to be addressed:

- How should formal education establishments respond to Cloud Computing developments?
- What is the impact of available Cloud Computing technologies on exercising educational policy, teaching practices, and on facilitating individualized learning processes?

3.2 Methodology

For the purpose of addressing the above stated research questions, a European network (namely, the School on the Cloud network), in which all educational sectors and levels are represented and almost all categories of educational stakeholders are included, has been set up to undertake a three-year research project (January, 2014 to December, 2016). The School on the Cloud network, whose development is in alignment with the Lifelong Learning Programme's ICT - Key Activity 3, consists of 57 partners including 21 Universities and teacher training departments, 9 NGOs, 8 schools, SMEs, research institutes, adult education and VET providers, a European professional association, and a library. Tasks of the network are: (i) the research of "state-of-the-art", (ii) the production of a series of core publications on the exploitation of Cloud in different educational contexts, (iii) the production of guidance resources, (iv) the establishment of methods and means for network members to share their findings and expertise, (v) the dissemination of research outputs within and beyond the confines of the network, and (vi) the establishment of links with other European-wide or nation-wide initiatives.

Research by adopting different points of view (i.e. the educational organization administrator's, teacher's, and learner's point of view) is achieved through the assignment of network partners to four Working Groups (WGs) according to their fields of expertise and interests. These Working Groups are: (i) the innovative Manager (i-Manager) WG, (ii) the innovative Teacher (i-Teacher) WG, (iii) the innovative Learner (i-Learner) WG, and (iv) the innovative Future (i-Future) WG. In order to optimize the project's management

and better monitor progress, a leader has been assigned to each WG. WG leaders along with the project coordinator form the project's Steering Group. Table 1 below contains descriptions of each Working Group and their tasks in terms of assigned Work Packages (WPs) and associated deliverables. Each deliverable of each WP constitutes part of one of a four-phase workflow that dictates a sequence for the implementation of each WG's tasks. These phases are: (i) awareness raising/motivation, (ii) review of literature/best practices/ available tools, (iii) development of guidelines, and (iv) dissemination of results and transfer of expertise. Deliverables marked with an asterisk have already been developed and are available to the public through the project's official website and dedicated social media websites.

Finally, given the number of participating institutions, an issue of concern is the coordination of members of the network and their collective activities. To this end, a number of events, planned to take place at regular time intervals, have been scheduled. These events are: (i) *network summits*, which are open to the public and take place on an annual basis with the participation of all network members, (ii) *WG meetings*, in the context of which members of each WG share outcomes of ongoing, or completed, activities and monitor progress against agreed upon time schedules, and (iii) *Steering Group meetings*, conducted with the participation of WG leaders and the project coordinator with the aim to evaluate progress and prioritize next activities. Figure 1 below illustrates key tasks relevant to the project's development.

Table 1. Description of the School on the Cloud network's Working Groups and their project-related tasks

WG name and description	Assigned Work Package (WP)	Associated deliverables
WG1 (i-Manager): Examines aspects of educational leadership, management and organizational change. Aims to identify and share technological, social, economic, cultural and other experiences in different educational contexts, as well as provide guidance to educational organizations.	**WP2**: Leading/ managing Cloud-based developments	**D2.1**. Education and the Cloud – a summary leaflet for leaders and managers (*) **D2.2**. Publication: policy, leadership and management issues **D2.3**. Implementation guidelines and advice **D2.4**. Workshop
WG2 (i-Teacher): Explores the impact of the Cloud on the roles of teachers and trainers and examines how Cloud-based developments can find their way in education. It attempts to identify barriers and required competences, review learning and teaching approaches, and provide practical and essential guidance for teachers and teacher trainers.	**WP3**: i-Teacher: innovative-Teacher	**D3.1**. Presentations on the impact of Cloud-based teaching and teacher education on teachers and trainers (*) **D3.2**. An online catalogue of platforms, tools and apps for teachers, trainers and educators (*) **D3.3**. A guidance leaflet on Cloud teaching and Cloud learning **D3.4**. Workshop on teachers' needs
WG3 (i-Learner): Brings together teachers and educators, schools, colleges, and adult education organizations with the aim to exploit the opportunities resulting from both formal and informal learning situations. WG3 will define personalized learning, and from existing best-practice case studies, will develop a guide on how to facilitate it.	**WP4**: Integrating the Cloud: personalized learning	**D4.1**. State of the art literature review of personalized learning and the Cloud (*) **D4.2**. Case studies of personalized learning **D4.3**. Guidance on personalized learning **D4.4**. Workshop on personalized learning
WG4 (i-Future): Deals with topics like the role and the impact of open (education) resources through the Cloud, new generation Cloud-based tools, and issues such as ethics. Efforts aim to attract the interest of organizations such as education and teacher associations, NGOs, and museums, as well as researchers, educators, school administrators and policy makers.	**WP5**: Future scenarios for Education on the Cloud	**D5.1**. A review of Cloud-based futures and methodologies (*) **D5.2**. Workshop on "Futures: thinking on the Cloud" **D5.3**. Cloud-based education: scenarios for the future **D5.4**. "The Future of Education on the Cloud"

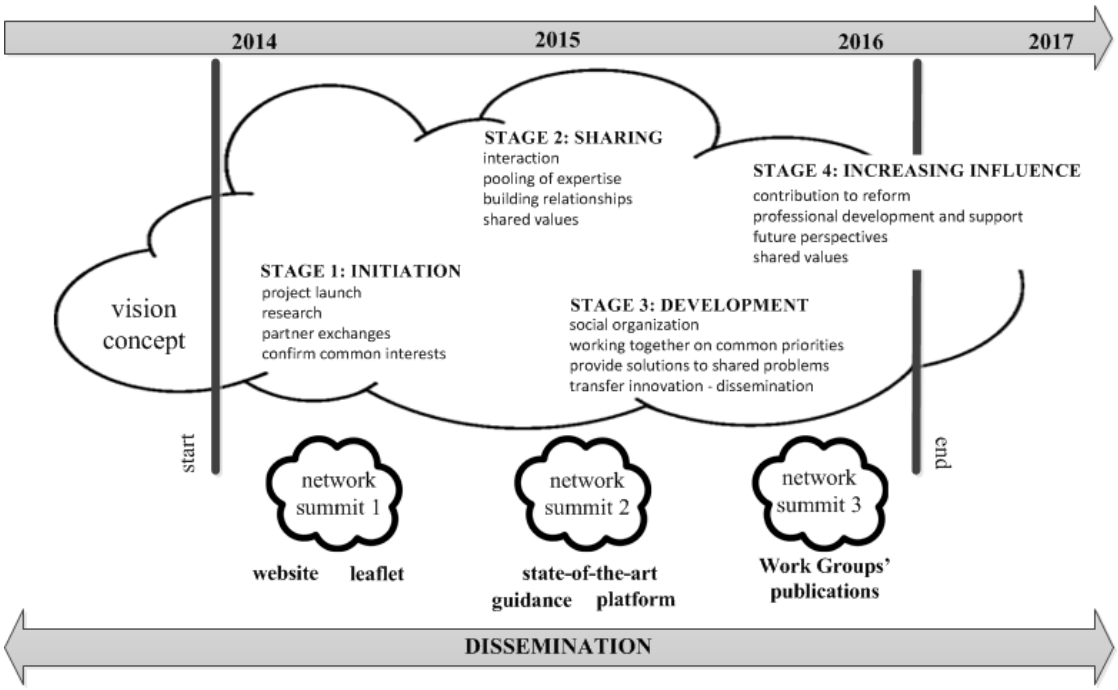

Figure 1. Tasks related to the adopted by the network methodology

3.3 User Needs Analysis: Perceptions of the Cloud and its Educational Potential

A user needs analysis was conducted prior to the first network summit (took place in March, 2014) with the aim to investigate perceptions of the Cloud and its characteristics, perceived educational affordances, beliefs about potential impact of the use of Cloud technologies on the roles of teachers and trainers, and reasons that may hamper uptake by organizations. This formal process also facilitated the reflection of network members on their expectations and offered a starting point for all Working Groups' research by providing input to defined tasks. User needs analysis was implemented through an online survey and with the participation of a sample of N=59 representatives of all network members.

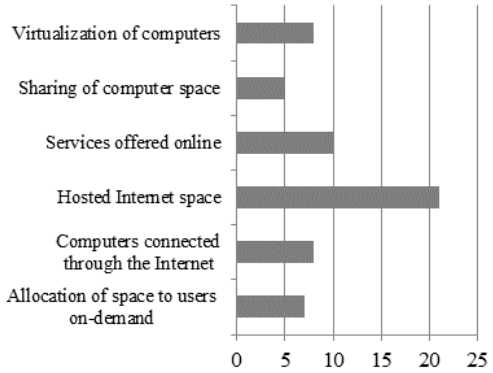

Figure 2. Perceived definitions of the Cloud

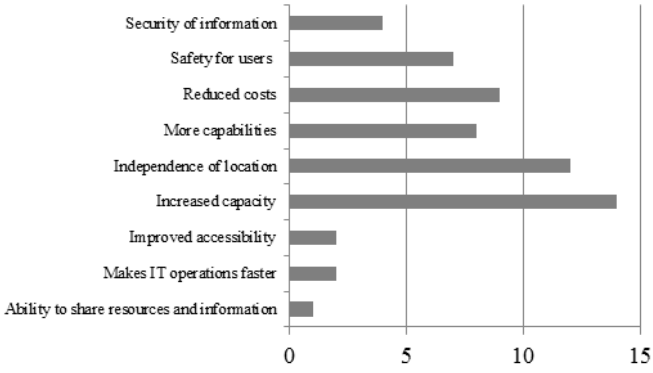

Figure 3. Cloud characteristics enabling educational exploitation

As far as perceived definitions of the Cloud are concerned ("*Which of the following applications does Cloud computing mean to you?*"), 35.6% of participants replied that the Cloud relates to hosted Internet space, 17.9% replied that it relates to services offered online, and 13.6% of responses offered views of the Cloud as computers connected through the Internet or virtualization of computers. Responses to this question

are illustrated in Figure 2 above. With respect to characteristics that may facilitate use of Cloud technologies in educational contexts ("*Which of these characteristics does the Cloud offer for education?*"), the most frequently cited responses were "*increased capacity*" (23.7%), "*independence of location*" (20.3%), "*reduced costs*" (15.3%), and "*more capabilities*" (13.6%). An analytical presentation of results is offered in Figure 3 above. Additionally, from responses to the question "*From your perspective, what makes using the Cloud in education innovative?*" the following list of issues arose: (i) freedom from hardware and disc storage, (ii) use in all forms of learning situation, (iii) potential for learning beyond traditional classroom situations, (iv), many innovative apps and tools, and (v) open access – MOOCs.

A key target of the user needs analysis process (having direct implications for research undertaken by the i-Teacher WG) was the investigation of perceptions of the impact that Cloud-based education may have on the roles of teachers and trainers ("*What impact does Cloud-based education have on the roles of teachers and trainers in education?*"). Data gathered from participants' responses reveal that a shift towards a Cloud-based education paradigm implies that teachers need to adopt the role of a catalyst for change, mentor/coach, co-learner, information manager, and facilitator of the learning process. Apart from that, a focus on issues impeding the uptake of Cloud-based solutions by institutions could not be left outside of the survey's scope. To this end, respondents were asked to rate, on a 0 to 9 scale, a number of potential reasons made available as part of a specifically-defined question (namely, "*On a scale of 0-9, consider the relative importance of these possible issues in influencing the take up of the Cloud for education in your organization.*"). Reasons that were rated the most, were: (i) security (6.47), (ii) culture of use (6.35), (iii) infrastructure and trust in the system (6.15), and (iv) capacity and management (6.13). Figure 4 below presents the full range of responses.

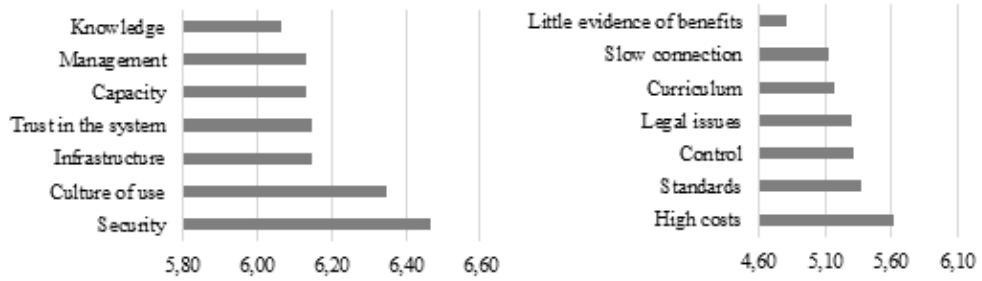

Figure 4. Issues that may hamper adoption of a Cloud-based paradigm by formal education establishments

A cursory review of survey findings reveals that perceived Cloud definitions and characteristics, as well as reported impacts and reasons affecting the Cloud's educational uptake, are in line with issues presented in literature. This conclusion has provided a good starting point for the network's efforts with ongoing research having the potential to lead to multiscale, sustainable Cloud-based educational solutions.

3.4 Focus on the Learner: Facilitating Cloud-based Personalized Learning

It is generally admitted that we cannot envision the future of education (on the Cloud) unless a paradigm shift (i.e. a fundamental change in methods of delivering education) takes place. In simpler terms, full exploitation of the Cloud in education may only be achieved through a paradigm shift from the teacher-centered approach to Cloud-based, student-centered teaching and learning (Koutsopoulos & Kotsanis, 2014). In this context, the aim of this section is to present the School on the Cloud network's vision for a Cloud-based, student-centered model of learning by attempting to draw links between affordances of Cloud technologies and contexts of use focused on the individual learner and specified by existing instructional strategies.

To begin with, services and tools made available through the Cloud can be utilized in support of direct instruction approaches. More specifically, according to Gonzalez-Martinez et al (2015), Cloud-based video-on-demand services can be exploited by educational organizations with the aim to deliver lectures to their students. Video-recorded lectures may benefit learners by allowing them to interact with educational content anytime, anyplace, at their convenience. By having immediate access to video-recorded educational material, learners are able to go through presented concepts as many times as they need and thus, develop knowledge at their own pace. Apart from that, provision of increased computational power through the Cloud

offers the potential for interactions with demanding, in terms of required hardware resources, learning environments, such as simulations (Gonzalez-Martinez et al, 2015). With the processing taking place in the Cloud, learners can get involved in simulation-based learning scenarios where learning occurs in a meaningful way through interactions with the medium.

Cloud technologies provide affordances for learning that not only fits the behaviorist learning paradigm, but their main advantage is that they are capable of facilitating learning in social contexts. As Denton (2012) points out, functionalities of Cloud-based applications and tools that support and promote collaboration and communication allow learners to become involved in joint learning activities. For instance, Cloud service providers offer online suites of tools with collaborative features, able to be accessed simultaneously by many users, which can significantly enhance the experience of remote interactions. Besides, according to the socio-cultural learning theory, learning at the individual level involves making meaning as part of the learner's engagement in appropriately structured, collective processes. Social interaction is an "*essential component*" of the problem-based learning approach (Eggen & Kauchak, 2006, p. 252) and can significantly enhance the benefits of involvement in project-based learning (Boss & Krauss, 2007, p. 65). Hence, incorporating Cloud-based applications and tools into appropriately designed problem-based and project-based learning scenarios facilitates learning in a way that is meaningful to the learner and relevant to real-world contexts.

By taking advantage of Cloud technologies there is also potential to maximize benefits from the delivery of inquiry-based learning scenarios. More specifically, lower-level Cloud services, such as storage spaces in the Cloud, can be used by learners (and teachers) to store, share and immediately access sets of data produced from their involvement in scientific inquiry (Abrams, 2012). By this way, learning activities are not confined to the school/university science laboratory and are not limited by strict time schedules. Additionally, through the provision of Cloud-based suites of productivity tools learners can engage in data elaboration processes, individually or in collaboration with peers, and present their findings. Elaboration of scientific data resides at the core of inquiry-based learning (Joyce, Weil, & Calhoun, 2009, pp. 159-187) and thus, providing learners with the appropriate Cloud-based tools and applications helps them to focus on inquiry-based activities rather than being bothered with issues of practical and technical nature.

However, the contribution of Cloud technologies to the personalization of learning can also be considered in terms of the means provided to teachers for the delivery of quality learning experiences. In such a context, the Cloud's potential lies at the emergence of Cloud-based Learning Object Repositories (LORs), able to balance supply and demand, improve availability of resources, respond better to queries for learning objects, and facilitate interoperability (De la Prieta et al, 2014). Furthermore, the existence of providers of Cloud services specializing in storing and managing of specific types of digital resources (JISC, 2012) may lead to new, decentralized LOR models enabling the storage of different types of learning objects to fit-for-purpose spaces. Developments of this kind offer teachers the opportunity to access quality material, either stand-alone or as part of integrated modules and courses, anywhere, anytime, according to their needs (Silva & Donert, 2015). Thus, teachers can create, edit and share innovative learning scenarios, with the use of media-rich content, by taking advantage of quality Cloud-based services and tools.

4. DISCUSSION AND IMPLICATIONS FOR FURTHER RESEARCH

During the last few years, educational organizations have begun to embrace Cloud-based solutions mostly in their attempts to reduce expenditures (Sclater, 2010; Sultan, 2010). However, the Cloud's actual potential lies at a number of affordances able to facilitate learning in many different contexts and based on a broad range of instructional strategies. For instance, Cloud technologies offer opportunities for individualized learning by allowing for anytime and anyplace access to media-rich learning resources, state-of-the-art tools and virtual learning environments. Furthermore, communication and collaboration functionalities of Cloud-based tools and applications help learners to make meaning at the individual level as part of their active participation in collaborative learning activities.

In this emerging landscape, the School on the Cloud network has been formed to explore how education should respond to new IT developments. Through a rigorous research methodology, the network's activities target at a systematic review of "state-of-the-art", considered both in terms of available Cloud technologies and existing Cloud-based educational initiatives, and the provision of guidance and support to stakeholders.

However, full exploitation of the Cloud in education requires careful reconsideration of the roles of teachers and learners. Therefore, by focusing on the individual learner, and with the help of well-established processes of expertise sharing among network members, the intention is to develop a body of knowledge regarding the impact of the educational use of the Cloud, as well as potential issues of concern. Research activities aim to result, among others, in publications providing incentives and guidelines for broad uptake of the Cloud and proposing sustainable solutions at various scale levels. There is much to do for bridging the gap between current practices and the School on the Cloud network's vision for Cloud-based, student-centered learning. To this end, the project consortium pursues dissemination of knowledge and expertise, by establishing links with other research initiatives, as well as stimulation of further research on a number of issues, such as: (i) evaluation of future scenarios of education on the Cloud, (ii) design, application, and evaluation of context-specific Cloud-based educational solutions that span across all levels of education, and (iii) development and testing of Cloud-based services and tools able to cater for special educational needs (e.g. assessment).

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