The Educational Cloud, Problems and Perspectives

Giovanni DIMAURO
Department of Informatics, University of Bari
Bari, Italy

Michele SCALERA
Department of Informatics, University of Bari
Bari, Italy

and

Giuseppe VISAGGIO
Department of Informatics, University of Bari
SER&Practices Spin Off, University of Bari
Bari, Italy

ABSTRACT

Cloud technology is rapidly spreading in educational institutions, sometimes replacing the in-house infrastructure with cloud services. This development seems driven primarily by the promised economic benefits and wider, efficient and accessible resources for students and teachers. The educational impact of this change, however, remains unclear. While traditional learning technically can be integrated or perhaps replaced by learning in the cloud, we need also to identify and formalize new strategies for the delivery and effective use of these resources and for measuring the educational benefit that they drift. In this paper, after a brief introduction on the development, technologies and pedagogical aspects of introduction of the cloud model in teaching and learning, are proposed the results of an investigation into the scientific literature of the last three years that outlines the areas in which research is most active. The papers taken into consideration here show a strong interest in the implementation of educational activities on the cloud model, also by developing countries. We found many research proposals but little real research and, therefore, little evidence. This implies that we are far from ready solution to be applied in the teaching processes. What is certain is that a new space has been opened where to carry out interesting research, both basic and industrial.
Keywords: cloud computing, e-learning, educational cloud, cloud-based campus, distance education.

1. INTRODUCTION

Cloud computing is a technology that provides on-demand access to a shared pool of configurable computing resources that can be provided and released with simplicity, real time and with minimal interaction with the service provider. More simply, the cloud can be considered a collection of hardware, software and other resources accessible through the Internet, and used to build a solution on demand (i.e. when needed) to provide a set of services to the applicant. Cloud technology provides an environment that offers new possibilities in teaching and learning and is viewed with growing interest from educational institutions.

Through the Internet, the cloud model is able to provide the most advanced software and educational materials, hardware and services to students and teachers even in the schools in the remote parts of the planet, without the need for onsite IT advanced skills. It allows teachers and students but also institutions (schools, universities and training centers) to access a huge amount of computing resources and storage both in scenarios where you need high performance (virtual worlds, simulations, streaming video, etc.) or a high number of clients as the Massive Open Online Courses (MOOCs).

Furthermore, providing students and teachers with proper tools, you can deploy computing resources for lectures and workshops based on the real needs of learning and teaching. For example, teachers can create virtual machines (VMs) on demand with pre-installed software and quickly implement digital labs. A university student who takes a course of mathematics could instead access the cloud from his room and get a physical or virtual server (and storage resources) and a copy of the software (such as Scilab) running on it to be used for individual study or for collaboration in project groups. Similarly, a primary school teacher could access the cloud and take a virtual machine for each of its students using a book creator, as part of its educational activities in the classroom. Some educational institutions are already using cloud computing to outsource email services, to provide collaboration tools and storage for students and to accommodate institutional virtual learning environments (VLE).

Other possibilities to effectively use the cloud model concern new learning scenarios where ubiquity, online tools and advanced remote collaboration come together to create innovative opportunities for education. Allowing applications to run as network services, cloud computing focuses in providing low cost solutions to educational institutions, researchers, teachers and students and is then seen with interest because it offers an enormous potential to improve efficiency and reduce

costs of installation, use and maintenance of numerous educational services, even if not really about teaching.

While the cloud model acquires popularity in delivering technology to educational world, greater attention should be paid to the factors that, from the point of view of students and educational institutions, can contribute to the successful implementation of cloud computing in educational contexts. In fact, if cloud computing solutions are used by a growing number of schools to provide applications and cloud-based services to teachers and students, what remains unclear, and then to define and promote, is the ability of cloud model to enhance the engagement of students to participate in community learning and to collaborate in research. It must be said that cloud computing brings with it new challenges compared to conventional IT models, such as security, performance, and interoperability that must now be taken into account.

Despite everything, the increasing efforts of the scientific community and industry demonstrates the clear desire to make the cloud model more effective and efficient and, given its enormous potential, the world of education can only take note of the need to program the adoption of cloud systems in the near future.

As we will see in this paper, research it is now distributed worldwide and the interest on the cloud model in education seem to focus primarily on the following areas: virtual laboratory, proposal of e-learning models, effectiveness and benefits of e-learning based on cloud, m-learning, virtual environments for collaboration, reducing the digital divide, digital campus.

2. TECHNOLOGY

Cloud computing is not a totally new concept, and has close relationships with other related technologies, such as utility computing, cluster computing, and distributed systems.

As mentioned in the introduction, it is essentially a distributed computing paradigm that provides access to virtualized resources, including computers, networks, storage, development platforms or applications that can be queried and configured by the user with a minimal interaction with cloud provider. In addition, resources can be quickly scaled to meet user's need, creating the conditions for having a considerable availability of resources at any time, if the need arises. Resource usage can be measured and this also allows the implementation of pay-per-use charging.

The cloud computing services are classified into three main types IaaS, PaaS and SaaS. The lowest level of abstraction, IaaS provides the user with computing, storage, networking and other resources on-demand, for example under the abstraction of a virtual machine. Examples of IaaS is Amazon EC2 providing virtual machines on demand. What enables the creation of virtual machines is called hypervisor: examples are VMware, Xen, Hyper-V and KVM. The hypervisor creates multiple virtual machines based on a real host, who share the real resources of the host machine, which can be installed dynamically and rapidly terminated when no longer needed.

The next level, PaaS, is usually built on IaaS level and is basically a cloud services operating system that serves as a development environment and provides hosting and management services; it provides developers with on-demand computing and storage so as to host, scale and manage web applications on the Internet through the provider data center. Software developers, IT staff and non-technical users can use PaaS resources. Among the others we cite Google App Engine (GAE) and Microsoft Windows Azure.

Finally, SaaS is a model of on-demand software deployed as a hosted service. User may access the environment made available on software to use, without installation and configuration. It consists of applications (such as Google Docs word processing or storage such as Dropbox) made available by a software provider and always accessible through a simple web browser.

3. PEDAGOGY

Cloud computing has grown also thanks to the progress of web services, Web 2.0, virtualization, grid computing, and can now benefit even in education, specifically in the case of mobile learning, distance learning and collaborative learning. Online courses, as the free courses at MIT, and the increasing number MOOCs suggest that online resources can be used for a large-scale learning. Usually these courses are not considered as alternatives to traditional ones, but they try to integrate and enhance traditional teaching and reach a much wider audience, that otherwise would not have access to such material.

The rapid growth and spread of cloud in education and training, need to meditate about issues ignored or not much taken into account: what is the overall impact of cloud computing in education? What aspects of cloud computing should be studied by researchers?

Really many people have unclear ideas on concrete meaning of cloud and how it can be used to improve teaching and learning. Few reports deal and concretely contribute to these themes, while are privileged generic contributions or proposal of research for cloud-service in education. Most of the considered papers address the collaborative aspect of the cloud in education but there is a widespread feeling that the way in which education can be improved (or transformed) by new technologies should be investigated deeply together with the investigation of how much this new technology affects traditional teaching and learning. In general, there was a lack of theoretical models, intrinsically linked to the cloud, through which pedagogy can find new life.

Other topics include the growth of interest in social interaction and collaborative work and this is shown by the growth in popularity of Google Apps: some studies show the significant improvement of the collaborative work between students and teachers using Google Apps. Other studies also report on strategies that give rise to an effective real-time collaboration among students in online spaces when collaboration is based on the use of cloud computing. Other investigations concern the pedagogical potential of web-based applications to create new learning opportunities in order to increase students' interest in science, technology, engineering and mathematics (STEM).

However, the potential of cloud computing in the improvement of education cannot be expressed only through the collaborative aspect. For example, mobility is another important feature offered and improved by the cloud model and it is necessary to develop conceptual models and define specific strategies to improve the effectiveness of teaching and learning. The concepts 'always' and 'anywhere' but also the limits of current devices and connectivity are crucial points of interest in the emergence of cloud computing.

Another relevant aspect is the possibility offered by cloud systems to store and share a large amount of data. Normally library is considered as one of the main focuses in schools and universities for its nature of 'collector of science' but also because is a place of study and exchange of experiences. It is clear that cloud-based digital library will make knowledge available to an immense number of students, like the Internet does, not even necessarily enrolled in a course of study and then also self-taught students, with pedagogical implications yet to be imagined.

4. TOPICS TO DEVELOP

Given that research should also be oriented towards the pedagogical impact, in fact, to date the major projects of cloud deployment in education are often oriented to reducing costs.

Cloud technology allows schools and universities to use less powerful computers (i.e. netbooks) to access the cloud in order to reduce costs for computing, storage and applications. In addition, many cloud-based applications have comprehensive feature set, and are compatible with common applications that can perform a wide range of activities and, therefore, fully satisfy the needs of users. For these reasons, many colleges, universities and lower schools in the United States and elsewhere are already working for a long time in the cloud. On the other hand, cloud computing shows conceptual, legal, ethical and practical problems. Maybe the most banal problem is that there are ideas, concepts and different models behind the term Cloud Computing and sometimes there are different ideas about it among professionals and among IT companies. This confuses users, likewise they feel uncertainty and insecurity when thinking where their data is stored on remote servers whose location, structure and properties is often unknown. Many legal issues may arise implementing our services in the Cloud. For example it is not clear who governs data protection, namely the country of origin of data or the country in which data reside, as well as the rules for refund for data loss: how to estimate the value of data stored at a cloud provider so as to define a fair refund? Similar questions concern privacy of personal and business data.

How much cloud increases our security in terms of data retention, even personal? Can we back up data stored by a third-party provider? And how much insecurity reduces the cost / benefit ratio if we are forced to backup data also if data are stored at the provider? Many of these questions have no easy answers, but this is a fertile ground for research.

5. LITERATURE REVIEW

We have seen that the adoption of cloud computing in education has come thanks to a great research effort. There is a large number of scientific papers facing this issue from different perspectives, trying to imagine and propose cloud services for education. In literature, there are still a few reviews of these contributions, while a coherent view of the challenges of current research would be useful to scientists from different fields to identify relevant problems and challenges where to focus their efforts. Businesses interest is relevant too, both for professionals, enterprises and, of course, educational institutions in order to identify opportunities for using the cloud in their own context. Our study, described in the following sections, firstly try to identify a set of terms commonly used in the international literature when you want to refer to the use of the cloud as part of e-learning technology and process. This study also identifies a considerable set of papers considered to be of real interest to researchers, developers and users and draws from it useful clues reported below.

6. MOST USED KEYWORDS

Our preliminary survey, in early 2015, concerns the identification of keywords most used together with cloud computing and e-learning. The research was carried out by searching papers published and included in the database IEEEXplore and Science Direct in the following way:

- keyword 'e-learning' on IEEEXplore - years 2010/15 - top 50 most cited work;
- keyword 'e-learning' Science Direct - years 2010/15 - top 50 most cited works. Filters: Journal 'Computers and Education'.
- keyword 'cloud computing' on IEEEXplore - years 2010/15 - top 25 most cited works + top 25 most recent works. Filters: journals & magazines, books & eBooks
- keyword 'cloud computing' on Science Direct - years 2010/15 - first 25 most recent works + top 25 most important works. Filters: Journals, books and reference.

This first survey made possible to identify the following set of terms frequently used in the scientific literature that can be used effectively to perform targeted searches:

Computer Aided Instruction, Educational Institutions, Electronic Learning, Elearning, Teaching, Education, Educational Courses, Distance Learning, E-Learning, Learning Management System, Distance Education,

to be used in AND with the words *cloud computing* or just *cloud*, such as in the case of the search in the database of ACM.

7. PAPERS SELECTION

The second phase of the investigation focused on the search and selection of published papers in four common databases with the above search string, with the aim to deduce for example the international distribution of research activity, the trend of research in recent years, type of publication and themes in which currently operates the majority of international scientific research. Obtained the lists, all papers have been inspected and selected by title or, in most cases, reading the abstracts and / or conclusions.

The research was carried out between January and March 2015 basing on search strings that, with different configurations, included the conditions identified; for example, this was the search string in IEEEXplore:

(Computer Aided Instruction OR Educational Institutions OR Electronic Learning OR Elearning OR Teaching OR Education OR Educational Courses OR Distance Learning OR E-Learning OR Learning Management System OR Distance Education) AND (Cloud Computing).

Filters applied: from 2012 to 2015 and, among others, editorial position almost always focused on Journals, Conference, Books, eBooks. Search in the ACM database and partly in Science Direct and Springer was based on the more generic term 'cloud' rather than 'cloud computing' to increase the number of

publications found. The number of papers selected is reported in table 1:

Database	Papers (on found)
IEEExplore	247 (on 1680)
ACM	9 (on 311)
Science Direct	36 (on 195)
Springer	140 (on 3142)

Table 1: Number of papers selected

After a further deep refining step we reduced the interesting papers to 401.

Then selected papers were further analyzed. The first analysis concerns the international distribution of active research in this area, which sees China and India leading publisher of research work in the field of cloud for education in the years from 2012 to the date of the search:

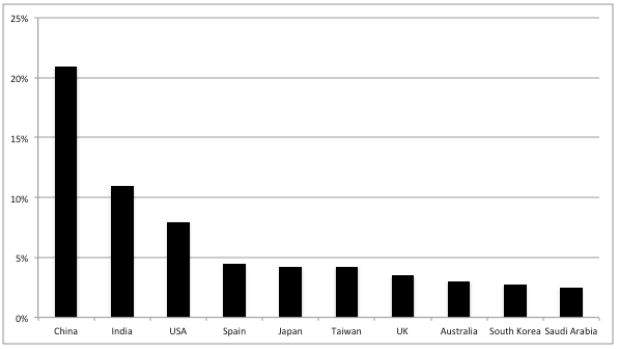

Figure 1: International distribution of active research

It is not a surprise that China and India are driving, at least in terms of number of papers published, the ranking of research on 'cloud in education': both wide countries, with urgent need to elevate the culture of many people and the impossibility to disseminate high level instruction in the traditional way; what a better way than cloud to diffuse e-education and e-training remotely, virtual labs, online tutoring and collaboration, involving few resources in terms of buildings and human resources? Only the United States follow closely, not mainly but also for the same need to cover a wide country, taking advantage of 'cost saving' promised by cloud. It is interesting also to note that these themes meet the interest of researchers in a very broad spectrum. The list in Table 2 reports the countries from which over 400 selected works; the overall result of research in Europe is poor.

China (84)	*India (44)*	*USA (32)*
Spain (18)	*Japan (17)*	*Taiwan (17)*
UK (14)	*Australia (12)*	*South Korea (11)*
Saudi Arabia (10)	*Germany (8)*	*Iran (7)*
Macedonia (7)	*Malaysia (7)*	*Romania (7)*
Arab Emirates (6)	*Brazil (5)*	*Canada (5)*
Indonesia (5)	*Nigeria (5)*	*Portugal (5)*
Cyprus (4)	*Morocco (4)*	*Poland (4)*
Russia (4)	*Turkey (4)*	*Croatia (3)*
Greece (3)	*Italy (3)*	*Serbia (3)*
South Africa (3)	*Thailand (3)*	*Czech Republic (2)*
Egypt (2)	*Estonia (2)*	*Ireland (2)*
Netherlands (2)	*Slovenia (2)*	*Tunisia (2)*
Ukraine (2)	*Vietnam (2)*	*Austria (1)*
Bosnia (1)	*Bulgaria (1)*	*Chile (1)*
Colombia (1)	*Guatemala (1)*	*Jordan (1)*
Kazakhstan (1)	*Kenya (1)*	*Mexico (1)*
Moldova (1)	*Palestine (1)*	*Qatar (1)*
Senegal (1)	*Slovakia (1)*	*Sweden (1)*
Syria (1)	*Venezuela (1)*	*Zimbabwe (1)*

Table 2: International distribution of research (2012-2015)

The chart in figure 2 shows a steady slight growth of the interest of researchers in the field investigated (2012 to 2015), while papers placement is focused on conferences, see figure 3, may be due to the immaturity of the field: research not perfectly focused and settled don't find a place in journals. Then a new scenario can be outlined where it is strong the need to carry out research, both basic and industrial.

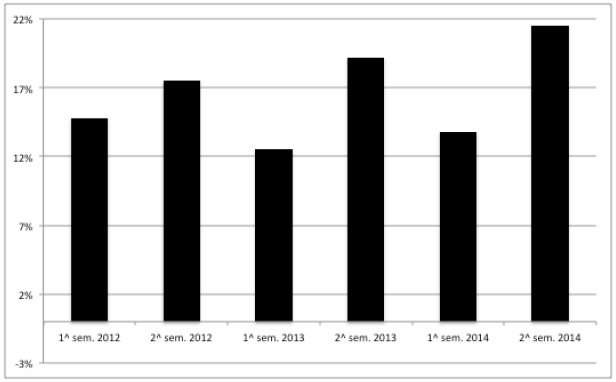

Figure 2: Trend of the interest of researchers

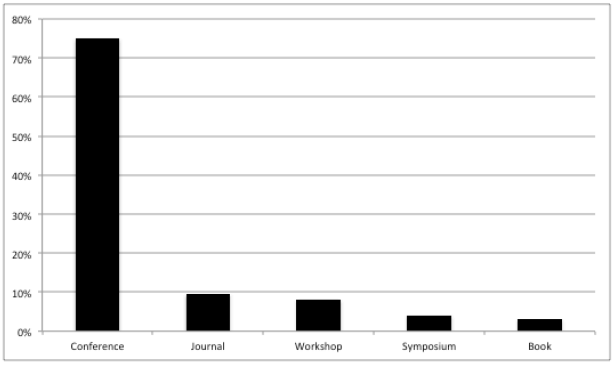

Figure 3: Origin of the articles

8. MAIN THEMES

The following analysis refers to more than 95% of the papers selected. As already mentioned, the panorama of research in the 'cloud in education' is very wide, but our desire was to make an

attempt to identify some macro-themes fitting the papers selected.

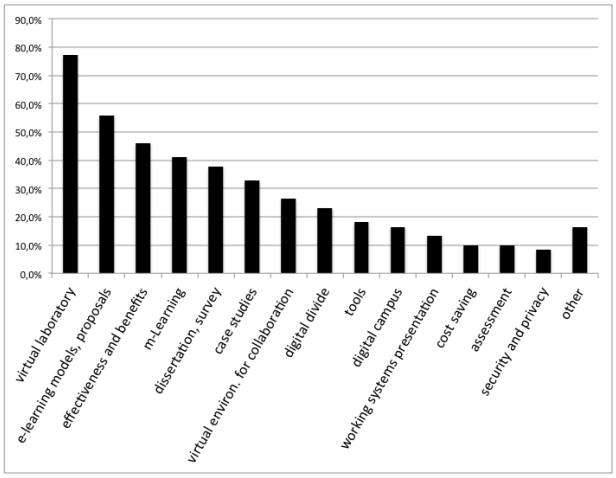

Figure 4: Main themes classification (2012-2015)

Here are some sections that describe the macro-themes identified, on the basis of the main topics dealt within selected papers.

A. Virtual laboratory

Practical skills are crucial to many curricula in schools of all levels; sometimes to acquire them it is more difficult than theoretical knowledge. Therefore, the use of laboratories is essential, but in the case of distance learning, it is not easy because students are physically far from labs. In this context, the research focuses on systems for creating and managing virtual remote labs cloud-based, to improve the participation and interaction of students in the experiments and practical exercises.

The topics range from the implementation methodologies of cloud computing for the development of remote laboratories to the creation of laboratories as a Service (Lasa) that allow users to create customized experiments. Some papers are dedicated to specific themes such as the laboratories of programming, computer networks, multimedia or specific software (Matlab, Scilab etc.) But special attention is devoted to the presentation of multidisciplinary laboratories for experiments on virtual platforms cloud-based. Much attention is also paid to the specific needs of educational institutions with more than one aim: high use of resources, minimize the administration effort required to keep real laboratories, facilitate the integration of centralized computing resources, storage, network and application, while another important goal concerns federated environments, namely the 'construction' of Saas laboratories shared by many educational institutions.

B. E-learning, models proposal

Advances in ICT provide the best IT solutions to the problems of the real world, and education is not an exception. The emerging technologies and platforms are now increasingly being used in the education process and these process change together with information and communications technology advances. The latest computing paradigm, that is cloud computing, is providing many opportunities to radically change the learning models, especially at all levels of education. In this context, research focuses on proposals, we would say very heterogeneous, about solutions, architectures, platforms etc., always based on the paradigm of cloud, to complement, enhance, share resources and educational activities during learning process.

C. Effectiveness and benefits

Global resource rationalization and the need to reduce costs, also in the education field, can not reduce quality. Indeed, it is compelling the need to improve culture and skills of students of all levels by updating education models, maximizing the use of technology and sharing resources. Based on the current development of ICT in education, research in this area analyzes the value of cloud computing introduction in the construction of new educational processes.

D. M-learning

In the last years there was a massive increase of demand for online courses and traditional e-learning systems are no longer sufficient to handle the increased demand for computing and content sharing. The cloud paradigm can face these growing needs, for example satisfying M-learning, i.e. a learning model that combines wireless technology and mobile computing, to which the wide dissemination of smart devices gave form and life. There are contexts in which M-learning is the only opportunity to benefit learning resources (e.g. areas where landlines and traditional computers are not widespread, as in some African areas where instead mobile connections are more efficient). The combination of M-learning and cloud computing enables access to educational resources to a large number of students. In this context research address the problems of M-learning and its integration with cloud computing, starting from the lack of specific educational resources to learning improvement, to the ability to implement secure, low cost, and scalable systems.

E. Introduction, survey, state of the art

Many papers deal in a general way the features of the available e-learning systems, the key concepts of cloud computing and the combination e-learning-cloud. Some papers analyze requirements, key techniques and also underline the need for protocols and standards to enable interoperability of different systems. These new learning models require new teaching methods, also based on 'mobile computing', and assessment evolution. Other papers discuss the benefits and risks of these new technologies. It was discussed whether these new architectures and technologies will enable a major step forward for improving the effectiveness of teaching that is active interaction, discussion in the classroom, laboratories that normally form part of the traditional teaching model.

In this section we included also few paper devoted to the state of the art of e-learning systems based on cloud computing.

F. Case studies

In this class was included research showing specific solutions based on the use of the cloud, such as the structuring of some courses (English, cloud computing, moral education, big data, Fourier transform, etc.), the use of cloud technologies to support students with attention disorders and other issues such as e-learning based on the integration of different sources (TV, radio, Internet).

G. Virtual environments for collaboration

The learning process includes a process of design thinking that promotes interaction among teachers and students. Also in e-learning such interaction should be ensured. Here research focuses on the development of virtual collaborative environments that enhance the effectiveness of remote educational process exploiting cloud technologies. Special attention is devoted to the virtual environments that can be 'lived' by using the technology that students use daily. These objectives can be achieved for example implementing cloud-based services to improve skills and resources exchanges among students, by using specific software for cloud-based collaboration (eg. SlapOS) or even designing special platforms for the cloud-based social networking, specifically designed for schools and universities, that can support information exchange, knowledge sharing and collaboration especially online.

In this class we also grouped the so-called 'student response systems' (SRS) since we considered them as part of the educational process based on collaboration. There exists a wide literature on SRS as part of educational research in recent years; it is known that they offer some advantages, for example support student interaction, provide immediate and anonymous feedback to teachers, and more generally can enhance the learning experience of students.

H. Digital divide

Education, training and research are the fundamental pillars on which to build progress. In the case of developing countries or the vast rural areas of countries that do not have the possibility of ensuring large investments for schools and universities, these problems are more relevant: literacy and access to information is not guaranteed to all citizens. Worldwide many initiatives are in progress to promote education based on deep use of ICT. However, the introduction of technology without considering the specific needs and problems of the recipient countries and people sometimes leads to failure since the problems to be solved in developed countries are partially different from those of developing countries. In this context some papers aims to study the contribute of cloud computing technologies to reduce educational gaps and training in specific geographical areas also with the aim of reducing digital divide. Cloud computing, e-learning and mobile technology and media can support students currently excluded from educational process an effective learning extended beyond classrooms.

Among other papers we cite an emblematic example as Syria, where the adoption of a model of this type has become almost mandatory because of the destruction caused by war in progress that makes impossible or not convenient to locate education centers in public buildings, but rather, locate them in virtual campuses.

I. Digital campus

Information and communications technology promotes the development of business processes and marketing of products and services, and, second, the spread of models for the use of technologies, aimed at reducing investment for the production and marketing of products. Universities and schools are organizations that offer services and that benefit from ICT. It is time to push over the use of such technologies, aiming at the achievement of real ecosystems ICT in education: we are speaking of 'virtual campus'. Virtual campus provides not only the virtualization of teaching activities, but the administrative too and all those typical of a university campus today. In this area they have been published many studies and dissertations on the ability to integrate and / or migrate IT-infrastructure components or IT IaaS systems and solutions to make university more accessible to a wider audience.

Research promotes also the federation of digital campus with the main purpose to share resources and reduce costs.

J. Assessment

Evaluation plays an important role in education. In the traditional classrooms, it is difficult to know the status of student learning and teaching evaluations are subject to a certain degree of subjectivity and delay.

In this context, some papers focuses on how to improve the quality and timeliness of continuous assessment during the teaching activities. In some cases they are based on the collection of data in classroom with the use of mobile devices interacting with cloud server-based application, making it possible also the management of large amounts of data. Other methods include applications that track and analyze student activities carried out in e-learning mode in order to monitor the activities of each student and to recognize the achievement of learning objectives.

Some other papers deal more specific topics such as remote evaluation for preschool children and those with specific disorders, for example as autism.

K. Security and privacy

With the expansion of cloud infrastructures, collaborative Web applications are used increasingly. For example, e-learning is an area where students, tutors and teachers share remote electronic resources and exchange information. However it is possible, as mentioned in other sections, that illegal accesses occur to accounts or that private information are acquired. Therefore, one of the challenges in the design of applications for collaboration is to ensure end-to-end security in order to preserve privacy and information integrity. Cloud computing is a young and not mature technology, so many studies are oriented for example to the design of safe digital campus. It appears surprising that this topic is not much favored by researchers given that it occupies, in terms of scientific works, less than 2% of the work taken into account in our study. Other interesting topics, although the low number of papers that deal with them, are the construction of tools to solve specific problems, the descriptions of real implementations of cloud-based e-learning courses, as well as the economic aspects of the introduction of cloud computing in training institutions.

9. CONCLUSION

Cloud technology is rapidly spreading in educational institutions, sometimes replacing the in-house infrastructure with cloud services. This development is driven primarily by the claimed economic benefits, and by the availability of efficient, accessible and scalable resources for students and teachers. Indeed most innovation seems to concern mainly the extension and improvement of web services. The educational impact of this change, however, remains unclear. While traditional learning technically can be integrated or perhaps replaced by learning in the cloud, we need also to identify and formalize new strategies for the delivery and effective use of these resources and for measuring the educational benefit that they drift. A valid course of study involves more than a mechanism for structured learning

not necessarily based on the intervention of a teacher / tutor. Although the availability of information and courses is growing considerably, becoming available to an increasing number of students, it appears mandatory the need to train students on how best to navigate the big amount of resources and data made available to them.

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