Smart Educational Systems and Education Clusters

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***Abstract*—**Investment and development are the keys of our society. The continuous improvement of the quality and performance of higher education is essential and it requires an effective correlation between all parties involved in the educational system. This can be done by aggregating all involved parties, both public and private, that provide educational services in an education cluster. The paper describes the characteristics of an education cluster and emphasizes the strong relation that must exist between the cluster and the business environment around it. This paper stresses the need to implement a smart system for higher education. Smart educational systems will be a real support for an education cluster, and this will help the development of partnerships between universities and businesses that activate in different industries, constructions, transports, communications, and information technologies.

***Keywords*—**cloud computing, education cluster, smart systems, smart educational system.

I. Introduction

THIS paper describes a current smart educational solutions and how it can be used in educational processes to improve the system. Smart educational solutions become an important and omnipresent support for development of educational systems.

The paper objective is to highlight advantages for using a smart educational system as a support for an existing or an education cluster initiative that will improve the quality and performance of higher education. The paper emphasizes the relation between education clusters and efficient educational systems.

The first part describes the theoretical elements behind the smart system solution and the benefits that it brings for the educational system. There is a continuous worldwide research to improve educational systems and processes by implementing the latest innovations in order to reach and support a knowledge based economy. Knowledge based economy is a state that the society can reach by promoting lifelong learning and by generating opportunities to put into practice studied elements. This level of efficiency and development is reachable by involving all stakeholders responsible for the education of future generations. To build a strong relation between all the parts of the education system it is proposed an education cluster that will include components of the education system, especially universities and post-university programs and institutions and elements from various business environments. Educations clusters and new technologies are helping learning organizations to work smarter, reducing training costs and to share knowledge more rapidly and more efficiently.

The second part presents the elements of an education cluster. It is highlighted its important role in generating qualified human resources, its contribution to the creation of new businesses or the support that it provides to other economic clusters. Based on specific characteristics of economic clusters defined by Porter [1-3] and on The Triple Helix [4] model, University - Industry - Government, this part describes the concept of an education cluster, its characteristics and structure.

The third part highlights the fact that smart educational systems represent a real support for an education cluster. It is essential to use existing and new IT infrastructure in the educational process and to identify points where it can be upgraded to improve performance in higher education.

Education is a fundamental element in every country's development, and consequently, smart education could be considered the most effective, reliable and modern method in personal and organizational development [5].

Education is one of the fundamental components that generate solutions to economy problems. Well educated and skilled people are the key elements for creating, sharing, disseminating and using knowledge effectively. A good economy requires a smart education system which is flexible and promotes creative, critical thinking, innovation.

II. Smart Educational Systems

Educational structures help define a society's long term health and prosperity, educating workers and leaders of tomorrow. To prepare students for a business environment and help them to gain the skills and knowledge, our educational

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system needs to become more instrumented, interconnected and smart. From this point of view, all over the world, several changes exist. Using smart systems to support teaching and to deliver education and training is one way to make some change. This solution will add new dimensions in educational activities [6] and the graduated students will contribute to the success of their communities.

Technology innovations that occur each day and the complexity of the present technology based society, that uses modern electronic communication devices and channels have generated a constant growth as volume [7] and diversity for services or activities in various fields.

The implementation of smart educational systems focuses on the efficient use of existing infrastructure and on modernizing it where is necessary. This approach is considered essential during an economic crisis when funds needed for education are insufficient. But most importantly, a smart education policy should redirect learning on the two key components of any education system: students and teachers.

Using a smart educational system, according to the latest data published by IBM in 2010 [8], teachers can analyze students data electronically - from academic results, to information regarding mobility and attendance.

A smart educational system, Fig. 1, is based on three elements:

- interconnection - sharing different technology resources used in education;
- instrumentation - accumulation of necessary data;
- intelligence - making decisions that enhance the learning process.

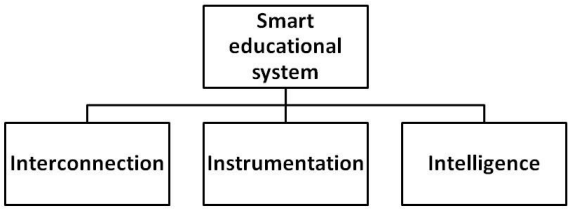

Fig. 1. Smart educational systems.

At the moment and for the near future, efficient interconnection is achieved through cloud computing systems. Cloud computing requires a large and complex network of servers that provide users with both storage, computing power as well as software applications, using only the usual web browsing devices. In this way costly investments in equipment, administration processes and personnel are eliminated. The implications of this trend in education are enormous, due to increased accessibility to information, as experts from World Bank have noted in October 2010.

Using technologies provided by cloud computing [9], students can access advanced educational content, software services, computing power and storage resources at any time. Based on an anytime, anywhere premise a student can access the same cloud resources from any infrastructure. The cloud can provide services that enable stakeholders of the educational process to follow students' academic achievements, their attendance and other reports. These solutions can be used to identify deficiencies in learning and give those interested the information they need to collaborate with students and teachers. Smart distributed systems based on cloud computing provide high quality distance learning opportunities for students localized in different parts of the country and beyond.

If an educational system becomes controllable, and has the functionalities that allow to collect and submit accurate data [10], such as attendance, grades, projects, essays and involvement in different activities, it can provide relevant information on

- the student evolution;
- university insights and processes;
- the educational elements that need intervention and improvement;
- the elements that give best results and must be extended on other parts of the system.

A smart educational system must provide solutions that will help both decision makers and beneficiaries:

- data systems that collect, integrate, analyze and present information on key performance factors such as attendance, knowledge and assessment criteria for school transfers;
- communication and data channels in education clusters that will allow the involvement of all stakeholders in the educational preparation of future generations;
- cloud computing in schools so that each pupil or student can access advanced educational content, software, computing resources and storage. As an example, North Carolina State University provides computing lab resources to schools and colleges throughout the state via a central service. Students, faculty and teachers are able to receive applications and a customized image of their content that meets their personal learning need [11].

A smart educational system can provide the tools and the understanding needed to make smarter decisions that affect the entire system. The system can provide data systems that collect, integrate, analyze and present reports on key performance factors such as attendance, evaluation criteria and transfers. Also, in competitive environments like an education cluster, educational organizations must take marketing decisions [12] to become more visible and more attractive.

The benefits of smart educational systems for parents, students, and academic staff are:

- understand student attendance patterns;
- gain a complete view of student progress;
- quickly identify problems in the student's academic evolution;
- identify strategies to help students to gain skills and qualifications needed to find a job.

On the other hand, for the educational system, the benefits can be:

- accelerate innovation;

- accelerate knowledge creation;
- accelerate economic impact of science with powerful tools for researchers.

Education is at the heart of human progress: educating students, driving innovation, and promoting social equity. The very best educational systems prepare people to be successful, productive, and engaged members of society. These systems provide appropriate knowledge, skills, and experiences, enabling students to obtain jobs that promote social equity and economic growth [13].

The parties interested in the educational process can obtain a complete view of student performance and take decisions at system level which will improve learning, correct problems identified in their early phases and instil a sense of motivation for reaching objectives.

III. Education Cluster

A first analysis regarding concentrations of firms was made by Alfred Marshall in his book *Principles of Economics* [14]. He highlighted the competitive advantage for firms in industrial agglomerations due to the network of suppliers and customers in that region. The cluster concept was outlined in the 90's and a first synthesis done in 1990 by Porter, [1-3], highlighted the beneficial impact on productivity. Also he has defined the concept as an important factor for the development of a competitive economy. Before Porter's analysis which is widely accepted in the scientific community as the most complete, other researchers as Sforzi [15] and Becattini [16] have observed the economic model and its benefits in the so called "*Italian district*". They have also added to the Marshal model the social aspect of the relations between cluster firms.

Based on the definition of clusters given by Porter as "*geographic concentrations of companies or institutions in a well-defined economic space*" [1], groups of companies placed in the same region conduct activities in a competitive environment to increase productivity and efficiency of the cluster and implicitly of each member.

The *Cluster Initiative Greenbook* research [17] represents a first major study that examines a large collection of cluster initiatives to analyze in depth various models of clusters, their evolution and a number of factors that influence their success or failure.

Another approach of clusters, from two perspectives, clusters evolution and clusters construction and reconstruction, has been done in *CLUSTERS Balancing Evolutionary and Constructive Forces* [18].

Important ongoing research projects in this area are at Harvard Business School - Institute for Strategy and Competitiveness [19]. Based on the research have been identified profiles for more than 800 clusters in 52 countries. Each profile contains up to 120 variables, which include:

- basic descriptive data: cluster name, location and employment degree of labour;
- statistical indicators on the competitiveness of the cluster, the export growth, innovation;
- qualitative indicators regarding reasons behind the cluster and growth / decline of its competitiveness.

These profiles were collected by analyzing a vast literature devoted to the analysis and description of clusters, literature that has been created in recent years by practitioners and university researchers. The project has a predominant orientation to the American continent and Asia, mostly Japan and China.

In the European Union (EU), it was launched in 2006, the European Cluster Observatory [20] project which is managed by the Centre for Strategy and Competitiveness (CSC) at the Stockholm School of Economics. This project is financed by the European Commission, Enterprise and Industry Directorate, through the Europe INNOVA initiative [21], and the Competitiveness and Innovation Framework Programme - CIP, which aims to encourage competitiveness of European enterprises. The project has identified in 2008 around 2000 clusters. At EU level, the cluster is considered an instrument of industrial policy, research and a competition and cooperation generator.

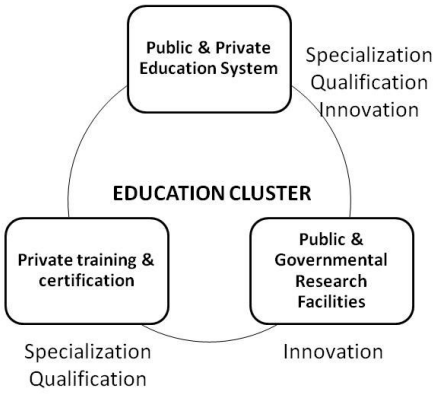

Fig. 2. Core elements of an education cluster.

These results and researches in the field of clusters are showing that this form of economic relationship is beneficial to all parties. Despite Global Productions Networks (GPN) and business processes carried out at global level, the geographical proximity of partners is a real advantage. Depending on the economic field in which cluster firms are conducting their business, clusters can be classified and named. Taking into consideration an educational process that helps individuals to gain skills and qualifications, the cluster is an education one.

The education cluster is based on the same basic principles of economic and industrial cluster. There are entities represented by educational institutions that collaborate, compete and manage an educational process. All these entities that form the cluster conduct processes that share knowledge and knowhow, teach. The competition between them is defined on the desire to be recognised as a leading educational organization and on the need for better candidates and more funding. Its core elements, described in Fig. 2 are:

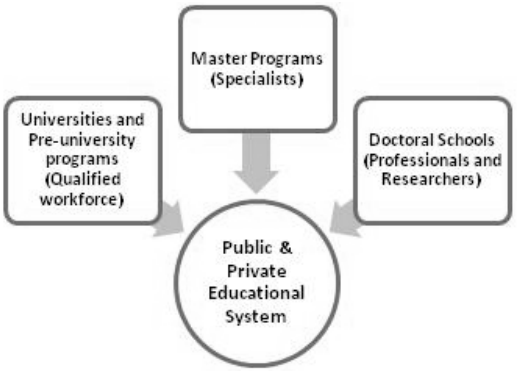

Fig. 3. Public and private educational system.

- the public and private educational system, Fig. 3, is defined by recognized educational institutions as universities, colleges, master programs and doctoral schools that compete in various scientific fields by preparing students and making them competent in their activity field; different structures in the educational system provide different levels of qualification needed by the business and production sector; the highest level of specialisation is provided by doctoral schools; at this lat level, individuals have the ability to research and to innovate, thus contributing to the innovative process that fuel industrial and technological clusters; the main role of the public and private educational system is to provide qualified workforce and skilled specialists that can adapt to different business environments; higher levels in the educational system, as master and doctoral schools, have the role to provide a more specialized human resource or high skilled individuals that are able to analyze, research and innovate; one aspect important for this type of educational system is the amount of time, between two to six years, needed to train and educate the graduates;

Fig. 4. Private training and certification educational system.

- the local academies and entrepreneurial initiatives, Fig. 4, generate small businesses that offer specialized courses and trainings; this educational organizations provide certifications in proprietary technologies, under the umbrella of large companies, or standard certifications recognized worldwide; these educational services are provided for short periods of time and the academies are flexible enough to keep the pace with their dynamic; mostly, the private training and certification component offer niche services by covering what is required at the moment; in this category can be included companies that collaborate with educational institutions and offer practice stages for students;

Fig. 5. Public and governmental research facilities.

- the public and governmental research facilities represent the highest levels in the education system because they have the leading role in generating innovation, in supporting the development of society; in this institutions are formed highly skilled professionals that come from the private and public educational system; these type of structures are the core elements for developing an education cluster;

The production process of the education cluster is separated into:

- the process of educating students and training future professionals in various areas of economic and industry activities; this process is based on knowledge;
- the economic process of production goods and services through the use of qualified human resources;
- the research and generation of new knowledge.

In terms of spatiality, this cluster may develop over broad geographical areas, but the physical proximity of entities in a cluster represents a major advantage for its success and for the outcomes quality. Although human resource can migrate, there are high costs related to this action. So education clusters are formed in geographic areas with strong academic institutions. Another argument for the physical proximity of cluster partners is the fact that the presence in the same environment and the direct contact between persons, allows the exchange of information in such more subtle forms [22].

From this point of view, an education cluster can be described starting from the description of "*socioeconomic entity characterized by a social community of people and a population of economic agents localized in close proximity in a specific geographic region*" [23].

Educational institutions public or private are economic agents because they function on the same principles as an industrial company. Maybe, for public institutions in harder to see the revenue from a financial point of view, but it exists and is defined by the quality of the educational system which is reflected by the qualification and professionalism level of the graduates. Also, in terms of research results he output is measured in terms of quality, applicability, innovation and

complexity.

All these public institutions receive public funds based on their results, so in economic terms, the output determined directly the revenue.

Benefits of being part of the cluster are transfer of information through direct communication or spillovers [24] and innovate through collaboration amid competition. In an education cluster this is done with more ease because the entities are knowledge based organizations. The transfer of information is done by allowing trainers, professors to collaborate with different educational institutions both public and private. The transfer of knowledge is done through people or can be acquired through learning. For research institutions or public R&D facilities the transfer of knowledge is done by accessing scientific conferences and journals that disseminate results obtained by the scientific community. This gives an insight into other research or opens the possibility for future collaboration. The policy of public research institutions is totally opposed to the one adopted by internal R&D departments of private firms because the public funding system requires the publication and dissemination of results.

The competition between institutions is fuelled by the desire to get higher ranks in educational classifications and thus better access to public and private funds or a larger pool of candidates. As the educational system is evolving by introducing new teaching techniques and technologies or by adapting curricula to current needs, competitors in the educations cluster will adopt improvements made by others to maintain or to increase their position in the education cluster.

Because education clusters generate qualified human resources, it contributes to the creation or it supports other economic clusters. A particular case that supports this fact is the most powerful IT cluster of India, Bangalore [25-26], that has reach over $ 15 billion in annual exports for IT products, in less than 20 years. In addition to government tax incentives, other important factors which are the basis for this cluster development:

- high level of skilled human resources;
- high percentage of English speakers;
- low cost of resources, especially labour force.

The first factor is very important because it is a very expensive resource that is generated over long periods of time, three to five years. From an economic perspective, any company is able to acquire new technology and to reduce the gap with top competitors, but in terms of human resources that may be not possible or would involve much higher costs.

At European level, strong education clusters are developed around prestigious universities. Silicon Fen, in the UK, is one of the strongest R&D oriented cluster. It has developed around the Cambridge University. In this case, the cluster concentration around a generator of qualified human resources and the financial support from the industry that invests in innovation has enabled the development of a University-Industry relation which brings significant benefits to both parties.

The clusters economic model and in particular the education cluster is based on knowledge. The economic process end product of the education cluster is the professional competence, a set of knowledge acquired by a person who uses them to take part in other economic processes. The input in this economic process is represented by people who accumulate knowledge, skills going through the education system. These people are then absorbed by businesses that will use their experience to produce goods or other knowledge.

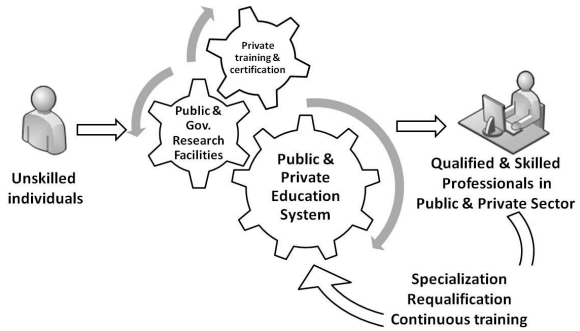

Fig. 6. The educational process inside an education cluster.

The educational process is continuous, Fig. 6, and even if individuals gain high skills and qualifications they will pursue the idea that through continuous training will be more efficient and will have more opportunities and possibilities for their professional evolution. That has been observed also by a study [27] regarding the increase efficiency of clusters based on the continuous specialization of the workforce. The study showed that specialized skills does not limit the employment opportunities, but instead is more attractive for an employee to further learn because cluster companies become more specialized.

The complexity and the size of the education cluster are influenced by the population size and by the need of qualified and specialized workforce. If the economic context of the education cluster is highly evolved and has a large and qualified labour market, then the need for training and certification will contribute to the grow of the education cluster as educational institutions are limited by personnel number and their qualification, budgets and other educational policies to grow indefinitely or to cover all required fields. Also, in the educational process there is a dependence relation between professional and qualification levels and the time needed to reach them.

The education cluster has strong connections with the surrounding economic which can be defined by different industrial clusters. Three of the most successful education clusters, around Stanford, MIT and Harvard and Cambridge have strong connections with well known IT and technology clusters [28]. Analysis of these technology clusters have emphasize that their continuous development has been greatly influenced by the proximity to the university centres [28].

Based on Markusen cluster topologies [29], an education cluster is like a hub-and-spoke industrial cluster in which

important universities and research institutions are surrounded by small private academies that fill the gap for short term and niche specializations. Because, educational institutions must adapt to local needs, social behaviour, culture you can't have a satellite organization. A state-anchored education cluster my exists in regions where the government policy is to allow and support only public educational systems but even in these situations universities have some form of autonomy regarding their internal management.

Currently, in many school systems, there is a missing link between graduate university students skills and those needed by businesses and industry. This was and is an intensely debated fact. Solutions based on defining skills or competences sets or standards are defined to reduce this breakage. A smart educational system provides an information database that can be used by companies to identify parts of the educational system that can provide necessary skilled human resources. This is a static approach because it is not based on the principle of supply and demand. It shows only what the educational system is generating but the business environment has no influence on it.

Implementing and sustaining an education cluster as a bridge between theory and practice, between components of the education system and the qualified labour market should be done in all three entities, universities, industry and government, by:

- implementing an information infrastructure that will enable rapid exchange of information between academia and business;
- defining new graduate programs, master's or doctorate, or adjust existing ones to generate human capital needed for research and development complex activities;
- promoting university-industry joint projects as a government policy;
- promoting the relations between business and education through tax benefits in the short or long term;
- promoting entrepreneurship to future graduates to enable the integration of academic knowledge in a real economic environment.

A smart educational system that can be configured and accessed by the both partners, the educational system and the business environment, can provide a real time communication channel that can maintain the link between them and adjust partially the gap between demand and offer in terms of qualified workforce. The education cluster will contribute to the economic growth of another cluster or of the surrounding business environment only if the two systems will communicate. In this way the demand in terms of qualified workforce and highly specialized specialists is correlated with the output of the education cluster. Because the business environment is a dynamic one, the communication with the education cluster must be made using efficient and distributed systems that will provide instant and actual information. This can be done integrating these requirements into a smart educational system already used in the cluster.

IV. Advantages of Smart Educational Systems

Knowledge as a process means to use in a complete manner all the information and data available and to link it with the potential given by people's skills, competencies, ideas, intuitions, commitments, motivations and also with the communication facilities provided by technologies. So, knowledge reflects in fact a way of using and understanding information. Smart educational systems are defined around that image of knowledge and around the integration of new technologies.

Knowledge, technology infrastructures, research, innovation and educational system are all interconnected, Fig. 7.

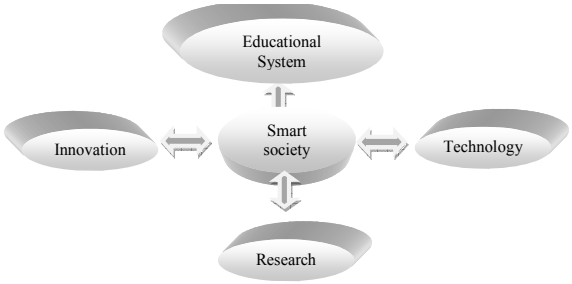

Fig. 7. Knowledge interconnection.

Today economic and social evolution is based entirely on generating and acquiring knowledge and this is an important reason to use efficiently smart solutions and systems that implement knowledge management processes.

Technologies have become more widespread at all educational levels, from elementary schools [30-31] to universities. The study of the smart educational systems concept is important because it's a fast growing trend and many traditional university have acknowledge that is helping them to conduct a successful type of education. Compared to the last decade, the smart educational systems concept is something doable and an efficient solution for an easy student-university interaction.

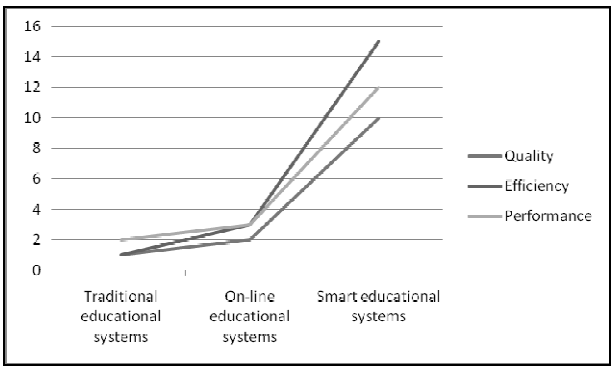

Fig. 8. Support of investment in smart educational systems.

With recent advances of technologies the new smart solutions for education are set to surpass online systems and traditional ones, Fig. 8, and this is every country desiderate.

Using smart solutions in the educational system will increase the quality, performance and efficiency in terms of teaching method, but also in terms of preparing students.

In this paper, are presented six reasons that could be used to support an investment in smart educational systems [32] and which lead to the improvement of quality, performance and efficiency:

- Flexible - learning can take place anytime, anywhere. Learning can happen across locations. These opportunities are offered by smart systems. Students are overtime on move, so they are interested in a more flexible kind of learning. The smart system must adapt to the student behaviour, its requirement and needs. This can be done by including a dynamic cognitive model of the student acquired knowledge and experience [33];
- Collaborative - using smart educational systems everyone access the same content; the system is communicating with students offering instant feedback and tips, results and educational content. This approach for learning reduce cultural and communication barriers between faculty and students because it offers communication channels that students like and know from other services like social and gaming networks. As a system, the architecture can provide public services to outside parties as the business environment; the system must eliminate the gap between the academic environment and the surrounding economic one facilitating communications and data exchange both ways; based on this platform, can be started future projects that will integrate educational activities with ones from different businesses.
- Motivational - multimedia resources which can be integrated in smart educational system can make learning a fun experience. With this kind of smart educational system, it is much easier to combine gaming and learning for a more effective and entertaining experience. This is a great point of view because most students are learning more and with more ease when they are do something as a game. Four young people the use of new technologies is something appealing and they embrace it and use it with ease; the educational system should use it to facilitate the delivery of knowledge;
- Accessible - the smart educational system is accessible virtually from anywhere and provides access to all available learning materials and services.
- Tools – the smart education system is able to collect and submit accurate data, like grades, projects, essays and other involvements in different activities. The system can provide relevant information on the students activities; interested parties can use the data to asses, observe and control the output and the efficiency of educational processes;
- Time efficiency - technology expands time and compresses space. There is no need for students to be in the same place at the same time to have a sense of live exchange; the system connects them and creates virtual groups that bring them together in the same virtual space. In this way, universities can build relationship between academic staff and students located on different continents.

On the other hand students need to engage in activities that allow them to analyze problems from different viewpoints, testing out assumptions, and redefining meanings. Students need to engage in social, collaborative exchange of ideas to confront hypothetical problems, general hypotheses, conduct experiments and reflect on outcomes.

Furthermore, in order for these implementations of smart educational systems in universities to be successful, teachers and technology developers should consider the following challenges:

- Mobility - the ability to participate in academic activities anywhere, gives students an opportunity to "get rid" of hours and to engage in activities that do not correspond with the requirements of the teacher nor the curriculum. The concepts of *anytime, anywhere* experiences encourage support of smart learning environments outside the classroom. Both scenarios present significant challenges for conventional teaching practices.
- Information - benefits of smart educational systems may be lost if their advantages are not highlighted so that students to become interested in their use. We need to bring information to students at not students at the information, because this is another classroom scenario but with technology.
- Accessibility - students can access only the resources they need from an existing information system package.

Globalization and technological change mean that tomorrow's workforce needs to have new skills, and be prepared to learn throughout life. This means learning in new ways: solving real problems, using multiple disciplines, and drawing on the very best content that the world has to offer [13].

The smart educational systems represent a real support for an education cluster. In the last years smart educational systems changed profoundly research, learning and innovation, by connecting systems, by recording, analyzing and integrating data. The educational system can be improved using technologies because it can become smarter and more efficient. In this process, universities can increase and sustain the quality of their student's results.

V. Conclusion

The smart educational system represents a real support for an education cluster which will generate a sustainable development of quality of our students because they will have access to projects developed by the business environment.

Results gained from using a smart system for an education cluster, allows:

- governments to provide legal/economic support to firms to promote the development of the education cluster;
- business operators to define or modify their competition policies in order to join existing clusters or to identify

areas where further clusters can be formed;
- analysis of cluster effects on the labour market, human capital and development and competitiveness policies;
- continuous development of the educational system which must generate qualified human resources and specialized based on industry requirements;
- creating a real link, based on knowledge, that will allow businesses to integrate students into real activities through periods of practice or joint projects.

To improve the quality and performance of higher education is recommended to involve all interested parties to implement efficiently smart educational systems.

The development of smart educational systems as support for education cluster depends on the evolution and the efficiently uses of the informational communicational technologies. In many countries the telecommunications systems infrastructure exists, but isn't use to the real value.

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