# THE ROLE OF UNIVERSITIES IN AN OPEN EDUCATION AND OPEN INNOVATION GLOBAL ENVIRONMENT

**Roumen Nikolov***

**University of Library Studies and Information Technology and Sofia University, 119 Bul. Tzarigradsko Shosse, Sofia 1784, Bulgaria, e-mail: e-mail: r.nikolov@unibit.bg*

**Abstract**: The paper analyses the changes which the ICT and open innovation drive in a global scale, such as: globalization of higher education, development of e-infrastructures for e-science, the open educational resources' movement, changes in the existing university and business models and the emergence of new ones, such as: Research University, Entrepreneural University, Digital University, Virtual University, Living Labs, Innovation University, University 2.0 and Global Campus. New generation research scientists and engineers, teachers and e-infrastructure career professionals will be required. The universities would need to develop new, hybrid degree programs combining library science with a scientific discipline. The e-infrastructures will impact the portfolio of skills and knowledge of the business people, the professionals and the citizens at large by enhancing communication and lifelong learning opportunities related to scientific inquiry and innovations. Some concrete examples based on the author's experience in a number of European projects will be presented.

**Key words**: knowledge society, e-learning, e-infrastructure, e-science, open educational resources, e-library, web 2.0, virtual organizations, university models, Living Labs, Global Campus Model

## 1. Introduction

The European Commission (EC) very clearly recognized the role of the universities in building Europe of Knowledge. The main aim is to improve "*the performance and international attractiveness of Europe's higher education institutions and raise the overall quality of all levels of education and training in the EU, combining both excellence and equity, by promoting student mobility and trainees' mobility, and improve the employment situation of young people*" (http://ec.europa.eu/europe2020). The EC aims at **increasing universities' excellence in research and teaching** [18]**.** The European universities have to identify the areas in which they have attained some excellence essential for Europe and to concentrate funding on them in order to support academic research. The commission supports not only intra-European academic mobility, but also mobility between universities and industry, thus opening up new career opportunities for young researchers. The EC reports also that the number of young technological (spin-off) companies created by universities has been on the rise in Europe. However, their average density is far smaller than it is around the American campuses. A major obstacle to better exploitation of the university research results is the way intellectual property issues are handled in Europe. In addition, it was identified that the European universities still do not have well-developed structures for managing research results.

Another important measure is to open up universities to the outside world and increase their international attractiveness and thus - preparing them to a broader international competition, especially with the American universities which attract the best talents from all over the world. The regions of the EU are supposed to play a very important role through the development of technology centres, science parks, and other cooperation structures between the business sector and the universities, and thus - to catalyze development of university regional development strategies and stimulate regional networking of universities. In all mentioned priorities and actions the **effective use of Information and Communication Technologies** (ICT) is of great importance.

## 2. Current and Emerging University Models

Operating in a very complicated world, universities and other higher education institutions have to adjust themselves to handle concurrently contrasting trends, such as: globalisation versus national needs; government steering versus institutional autonomy; harmonisation versus diversity; public versus private sectors; basic versus applied research; competition versus collaboration; and intellectual property versus intellectual philanthropy [17]. They adopt some characteristics of the current and the emerging university models, such as Research University, Entrepreneural University, Digital University and Virtual University.

A distinguished characteristic of a **Research University** is that it puts great importance on the creation of new knowledge, applies new knowledge to solve important societal problems and contributes to improving the quality of life. The Carnegie Classification of Institutions of Higher Education definition, a **research university** provides doctoral degree granting - "*at least 10 doctoral degrees per year across at least 3 disciplines, or at least 20 doctoral degrees overall*" (carnegiefoundation.org). However, while most of European research universities try to integrate education, research and innovation at a MSc and PhD level, many of the American research universities target the BSc level as well [4]. The research universities can offer a **learning environment** which is not typical for the small colleges and non-research universities. A baccalaureate student who studies in such environment develops his or her own research capabilities. The research universities could be both **student-centered and research-centered** through *a "synergistic system in which faculty and students are learners and researchers, whose interactions make for a healthy and flourishing intellectual atmosphere*" [4].

The America's research universities typically have an **international orientation -** they attract students, particularly at the graduate level, from many parts of the world, thereby adding valued dimensions of diversity to the community. The international graduate students often become teaching assistants, so their presence becomes a part of the undergraduate experience. And many research universities offer an array of **interdisciplinary programs** seldom available in smaller institutions. The graduates of these programs make the names of the American research universities recognized and respected throughout the world. The concept of integrated education at a research university requires **restructuring both the pedagogical and the management aspects of the university**. Because research universities create technological innovations, their students should have the best opportunities to learn state-of-the-art practices. The international organizations, such as UNESCO, OECD and World Bank, emphasise on the importance of research for the quality of higher education as well and the **importance of developing and sustain research capacity** [*32, 42, 43*]. The global models embrace research universities that see their mission as transcending the boundaries of the nation-state, educating for global perspective and advancing the frontiers of knowledge worldwide [25, 26, 27].

The framework of **Entrepreneurial University** was defined by Clark [6]. "*Entrepreneurial*" is considered as a characteristic of the whole university systems, i.e. the entire universities and their internal departments, research centers, faculties, and schools. The concept is derived from '*enterprise*' and puts attention on the willingness to take risks when initiating new practices whose outcome is not certain. An entrepreneurial university actively seeks to innovate in how it operates. It seeks substantial shift in organizational character in order to better perform in the future. Capitalization of research findings is one of the primary features of an entrepreneurial university. The main characteristic of such university is that it "*understands the commercial value of knowledge"* [6]. Clark identifies five elements that constitute the minimum of entrepreneurial actions for an entrepreneurial university. The degree of implementation of each of these actions provides a set of indicators for successful transformation of a university towards the framework of an entrepreneurial university. These actions are:

- Strengthening the steering core;
- Expanding the developmental periphery;
- Diversifying the funding base;
- Stimulating the academic heartland;
- Integrating the entrepreneurial culture.

Clark describes several case studies of universities which managed to become entrepreneurial [5, 6]. Most of them have established specialized units and structures, such as: science parks, incubators, technology transfer offices, liaison groups, strategy committees, R&D outreach offices (marketing, spin-offs), alumni networks, fund-rising initiatives, flexible load structure (education, research, industry), etc. The **Science Park** and **Knowledge Park** models are used by the entrepreneurial universities as instruments for establishing better **links between universities and industry** and for **brain-gain**, i.e. for attracting back the talented specialists to the countries of origin [19]. These models have their origin in the model of of the early fifties when the Stanford Research Park (1951) and the Cornell Business and Technology Park (1952) were established. Today, the Stanford Research Park has 140 companies in electronics, software, biotechnology and other high-tech fields and employs 23,000 persons (lbre.stanford.edu/realestate/research_park).

In order to become “*enterprise like organizations*” the universities tend to adopt ICT not only for e-learning, but also for management and administrative purposes. The most critical challenges that the campus information technology leaders in US were facing in 2008, were: security and Enterprise Resource Planning (ERP) systems along with change management and e-learning [14]. An emerging issue was recognised, namely “c*yberinfrastructure”* - hardware and software systems, distributed computing, data, communications technology and tools for collaborating of the research communities.

There exist some European higher education projects that aim to integrate the ICT into all university activities. For example, Technical University in Munich is developing a **Digital University** project [3]. The university re-aligns its ICT strategically in co-operation with the Leibniz Supercomputing Centre. This re-alignment follows an overall university strategy by means of closely interconnected projects in the areas of organisation, campus management, e-learning and ICT infrastructure. In 2004 University of Edinburgh started a “*change project which would include the implementation of a new student system, as well as fundamentally reviewing the way processes were carried out to identify shared solutions*” (www.euclid.ed.ac.uk). The primary objective of the project was to develop a “*streamlined, modern approach to interacting with enquirers, applicants and students which reflects our international standing and the calibre of our teaching and research*”. In 2002 the author initiated a pilot e-university project at Sofia University which evolved into an *eCampus* university model [26, 29].

**Virtual University** (**Virtual Campus**) can be considered as a "*metaphor for the electronic, teaching, learning and research environment created by the convergence of several relatively new technologies including, but not restricted to, the Internet, World Wide Web, computer mediated communication*" [41]. The notion of “*campus*” reflects the American traditions in higher education. Turner states: “*As a kind of city in microcosm, it (the campus) has been shaped by the desire to create an ideal community, and has often been a vehicle for expressing the utopian social vision of the American imagination. Above all, the campus reveals the power that a physical environment can possess as the embodiment of an institution's character”*[39]. Although not many universities are “*campus universities*”, any university could afford building its own virtual campus. In this respect it would be more appropriate to use the term “*virtual campus*” rather than “*virtual university*”.

Appart of competition between universities, a clear **need for cooperation** between them is of crucial importance. Many universities use the partnership as a means of **entry into the global e-learning market and to penetrate less economically advanced countries** [2]. The partner institutions from the less economically developed countries bring adaptation to local culture, language benefits, local or national accreditation, sharing of costs and risks, and access to neighbouring markets or markets with similar language and culture. These all are considerable benefits for a partner from a more developed country as well. Many countries have announced national virtual university initiatives of various kinds [8]. Some of these initiatives are intended to extend and enhance local provision while others are targeted at international markets.

## 3. New Technology Advances

The technology environment that is related to higher education is changing very fast, especially with the advent of the Web 2.0 technologies and cloud computing. The global education movement gave rise to another one, namely – **Open Educational Resources** (OER), which demonstrates great potential to overcome the demographic, economic, and geographic educational boundaries and to promote life-long learning and personalised learning. The term “*Open Educational Resources*” was adopted at a UNESCO meeting in 2002 in order to refer to the **open provision of educational resources**, enabled by ICT, for consultation, use and adaptation by a community of users for non-commercial purposes [8]. A definition of OER is: “*digitised materials offered freely and openly for educators, students and self-learners to use and reuse for teaching, learning and research*” [33]. For instance, Share.TEC (share-tec.eu) could be considered as a European digital library - OER in teacher education, and OpenScout (openscout.net) – as a European digital library - OER in the field of management education and training [26, 38]. According to OECD, there are more than 3000 open access courses (opencourseware) currently available from over 300 universities worldwide. For instance:

- **MIT OpenCourseWare** (ocw.mit.edu) is the most popular example of institutional OER model - they published on the Web more than 2000 courses which are made available to educators and learners worldwide at no cost;
- **OpenLearn initiative** (openlearn.open.ac.uk) launched by the UK Open University to make a selection of their materials available for free use by anyone and to build communities of learners and educators around the content using a range of tools and strategies. Currently more than 600 free online courses are available;
- **OpenCourseWare Consortium** (ocwconsortium.org) - a collaboration of more than 250 higher education institutions and associated organisations from around the world creating open educational content using a shared model.

Special case of OER are the **open textbooks** [16]. The cost of textbooks in higher education is usually paid directly by the students and their parents, and it is now a substantial part of the total and rapidly increasing cost of higher education. At the same time the cost of textbooks has risen, their usefulness in the teaching and learning process in higher education is declining as more material is available for free on the internet and neither the pedagogical approach nor the learning assessment process is well tied to them. A model of a *SmartBook* based on the new technologies emerged: dynamic, interactive, regularly updated (including by users), localized, customized, remixed, etc [21]. Open courses available on the web can also be the **center of communities of students and teachers.** These books and communities could be employed in teacher professional development in ways not possible or not as easily attainable with static texts. The open textbooks, as well as all OER movement, are very important instruments to approach the educational gap in the developing countries.

Some recent OER developments are related to building **open repositories of research publications** and other research outputs, e.g. – Dspace at MIT (dspace.mit.edu), DSpace of the TENCompetence project (tencompetence.org), Open Research Online of the UK Open University (oro.open.ac.uk), TeLearn (telearn.org), the OpenAIRE initiative of the EC (openaire.eu), etc. The Dspace at MIT Thesis Collection, for instance, contains more than 20 000 items. Open access is critical to ensure fast and reliable access to EU-funded research results, in order to drive innovation, advance scientific discovery and support the development of a strong knowledgebased economy (openaire.eu). Sofia University and other Bulgarian partners have established their open repositories of research publications and other research outputs (e.g. research.uni-sofia.bg) that are linked to OpenAIRE and other European digital repositories [26, 38]. They have jointly developed also thematic digital repositories and services, such as Share.TEC (share-tec.eu) and OpenScout (openscout.net).

The **e-infrastructure** (cyberinfrastructure) is a combination of hardware, software, services, personnel and organization, which provides a wide range of services for the global research communities, such as [1]: high performance computation services; data, information and knowledge management services; observation, management and fabrication services; interfaces and visualization services; collaboration service. The service layer is built upon base technology for computation, storage, and communication. E-infrastructures should enable research communities and projects to rely on an effective, application specific and interoperable **knowledge environments for research and education**. New types of scientific organizations and supporting environments are emerging, e.g "*laboratories without walls*", colaboratory, grid community, e-science community, and virtual community. It is needed to "*enable, encourage, and accelerate this grass-roots revolution in ways that maximize common benefits, minimize redundant and ineffective investments, and avoid increasing barriers to interdisciplinary research*" [1].

The term "*e-infrastructure*" refers to a new research environment in which all researchers - whether working in the context of their home institutions or in national or multinational scientific initiatives - have shared access to unique or distributed scientific facilities (including data, instruments, computing and communications), regardless of their type and location in the world [12]. Increasingly, new types of scientific organizations and supporting environments for science based on research communities are emerging. They can serve individuals, teams and organizations in ways that revolutionize the research practice. The industry could be an important partner in development and deployment of e-infrastructure, but it could also benefit from it. The e-infrastructure could be a platform for coinvestments building new partnerships by universities and industry and thus – catalyze new organizational forms for knowledge creation and education in the digital age [1].

The recent developments in the area of e-science digital repositories and e-infrastructures in Europe (http://e-scidr.eu/) aim at embedding them into "*a single science information space that serves multiple stakeholders and permits multiple perspectives: for science, scientists, researchers, students, schools, the publishing community and industry*" [13]. Such e-science repositories and e-infrastructures should embrace all EU countries and target their specific needs, and thus - to bridge differences between the well developed and less developed countries in the field [13]. There are many examples of implementation of e-infrastructure projects, such as:

- The **European Grid Infrastructure -** EGI (egi.eu) project is funded by the EC and aims to build on recent advances in grid technology and develop a service grid infrastructure which is available to scientists 24 hours-a-day. It was created (on the basis of several preliminary projects and initiatives) on 8 February 2010 to coordinate and maintain a sustainable pan-European infrastructure to support European research communities and their international collaborators. EGI is the **largest multi-disciplinary grid infrastructure in the world**, which brings together more than 140 institutions to produce a reliable and scalable computing resource available to the European and global research community. At present, it consists of approximately 300 sites in 50 countries and gives its 10,000 users access to 80,000 CPU cores around the globe. EGI cooperates with the Open Science Grid – OSG (opensciencegrid.org), iniative supported by the Nationals Science Foundation (NSF) in the USA which aims to advance science through open distributed computing;
- **nanoHUB.org** was created by the NSF-funded Network for Computational Nanotechnology – NCN (nanohub.org). NCN is a **network of universities** with a vision to pioneer the development of nanotechnology from science to manufacturing through innovative theory, exploratory simulation, and novel cyberinfrastructure. Many students, staff, and faculty are developing the nanoHUB science gateway while making use of it in their own research and education. nanoHUB.org is designed to be **a resource to the entire nanotechnology discovery and learning community**. Computation and software is a cross-cutting theme that connects computer scientists and applied mathematicians to problem-driven scientists and engineers, to address large scale problems and develop community codes for nanotechnology.

E-infrastructure and virtual organizations are enabling new form of learning: **learning through interactive visualizations and simulations** [31]. In order to realize these radical changes in the processes of learning and discovery, **cyber-services also demand a new level of technical competence from the workforce and citizens** [31]:

- **Future generations of research scientists and engineers**. The new tools and functionality of cyberinfrastructure are transforming the nature of scientific inquiry and scholarship. New methods to observe and to acquire data, to manipulate it, and to represent it challenge the traditional discipline-based graduate curricula. Increasingly the tools of e-infrastructure must be incorporated within the context of disciplinary research;
- **Teachers and faculty**. To employ the tools and capabilities of cyberinfrastructure enabled learning environments effectively, teachers and faculty must also have continued professional development opportunities. Undergraduate curricula must also be reinvented to exploit emerging e-infrastructure capabilities and the students should be able to do e-infrastructure-enabled scientific inquiry and learning;
- **E-infrastructure career professionals**. Ongoing attention must be paid to the education of the professionals who will support, deploy, develop, and design current and emerging e-infrastructure. For example, the increased emphasis on data rich scientific inquiry has revealed serious needs for digital data management or data curation professionals. Such careers may involve the development of **new, hybrid degree programs** combining library science with a scientific discipline;
- **Business and industry workforce**. The e-infrastucture will impact the portfolio of skills and knowledge the business people and professionals should strive to achieve through professiona certification training continual workplace learning;

- **Citizens at large**. E-infrastructure extends the impact of science to citizens at large by enhancing communication about scientific inquiry and outcomes to the lay public. E-infrastructure enables lifelong learning opportunities as it supports the direct involvement by citizens in distributed scientific inquiry.

The **vision of Europe** is that by 2030 a scientific e-infrastructure that supports seamless access, use, re-use, and trust of data will exist [11]. This will have impact in many directions:

- **All stakeholders**, from scientists to national authorities to the general public, are aware of the critical importance of conserving and sharing reliable data produced during the scientific process.
- **Researchers and practitioners** from any discipline are able to find, access and process the data they need. They can be confident in their ability to use and understand data, and they can evaluate the degree to which that data can be trusted.
- **Producers of data** benefit from opening it to broad access, and prefer to deposit their data with confidence in reliable repositories. A framework of repositories work to international standards, to ensure they are trustworthy.
- **Public funding rises**, because funding bodies have confidence that their investments in research are paying back extra dividends to society, through increased use and re-use of publicly generated data.
- The **innovative power of industry and enterprise** is harnessed by clear and efficient arrangements for exchange of data between private and public sectors, allowing appropriate returns to both.
- The **public has access** to and can make creative use of the huge amount of data available; it can also contribute to the data store and enrich it. All can be adequately educated and prepared to benefit from this abundance of information.
- **Policy makers** are able to make decisions based on solid evidence, and can monitor the impacts of these decision. Government becomes more trustworthy. Global governance promotes international trust and interoperability

The e-infrastructure allows the virtual research labs to conduct experiments "*in silico*", that enables new models of learning, teaching, doing research and business. Thus, the virtual research labs can become "*real*" – the researchers with different backgrounds could conduct global experiments remotely in real time and can collaborate on the same set of data from different perspectives.

The model of **Global Research Library** (GRL) is also emerging (grl2020.net). The fast development of the Web 2.0 technologies, OER and e-infrastructures are driving changes in the library model as well. Several best practice cases are reported, e.g. in the area of Nanotechnology, Earth Sciences, High Energy Physics. Some of the key challenges are:

- The expectations of faculties and students, now and in the future, will be growing;
- The global research libraries will transform the university mission in a technology enabled world;
- There is need of investments and focus in the face of limited resources, conflicting priorities, proliferating user groups and often competing clientele.

The GRL of the future should be: multi-ethnic, multi-cultural and multi-lingual; a collaborative and global environment, which emphasises the ethical issues surrounding data; purposefully inclusive to different cultures. Building pan-European electronic libraries is among the main priorities of the EC. A typical example of such libraries is Europeana (europeana.eu).

## 4. The Living Labs Model

Living Labs can be defined as "*an environment for innovation and development where users are exposed to new solutions in (semi) realistic contexts, as part of medium- or long-term studies targeting evaluation of new solutions and discovery of innovation opportunities*" [15]. Recently emerged, Living Labs represent an **open innovation infrastructure** including many innovation stakeholders - companies, universities, research organizations and community, developers, local and regional authorities and end-users, involved in early stage innovation processes for complex products and services development. They have been already applied in various settings and have proved their efficiency. Living Labs is an evolving concept, fast spreading around Europe supported by the European Network of Living Labs – ENoLL (openlivinglabs.eu). This is a form of user-driven open innovation ecosystem, based on a partnership which enables users to take an active part in the research, development and open innovation processes. Living Labs represent a research methodology for sensing, prototyping, validating, and refining complex solutions in multiple and evolving real life contexts [24]. They bridge the innovation gap between technology development and the uptake of new products and services. They allow early assessment of the socio-economic implications of new technological solutions by demonstrating the validity of innovative services and business models and become the main testbeds for development of innovations. Living Labs are organized on regional principle, enhancing local knowledge sharing by involvement of the main stakeholders in specific industry areas. ENoLL highlights the opportunities for increasing collaboration effect by sharing best practices and widely disseminating Living Labs success stories within European perspective. Many universities are active participants in these success stories. For instance, the Bulgarian Virtual Services and Open Innovation (VirtSOI) Living Lab aims to integrate a broad vision for virtual services development and implementation within the society related to different sectors, such as: e-Learning, e-Government, e-Health, e-Content, e-Inclusion, etc. In this respect the VirtSOI plays the role of a regional living lab and an active marketplace platform for regional expertise/innovation/service seekers and providers. After reaching a level of maturity, the VirtSOI Living Lab started making efforts to incubate a set of service-oriented living labs targeting different industrial and public sectors. The first pilot living labs are: the Multilingual e-Content and e-Library (MLeCeL) Living Lab (livinglab.itd-bg.eu), the Serious Games Living Lab (seriousgame.it.fmi.uni-sofia.bg) and the Internet of Things (IoT) e-Health Living Lab - in the framework of the FP7 ELLIOT Project "*Experimental Living Lab for the Internet of Things*" (elliot-project.eu).

## 5. The Global Campus Model

The Global Campus Model (GCM) is based on some advanced ICT and incorporates the main characteristics of the Research, Entrepreneurial, Digital and Virtual University models [25, 26]. The GCM universities considers their mission as transcending the boundaries of the nation-state, educating for global perspective and advancing the frontiers of knowledge worldwide. The GCM is intrinsically global since the ICT provides natural means to cross borders. The GCM adopts the assumption that the "*current educational reform is driven by three major factors - asynchronous space and time, responsive environments, and virtual reconstruction*" [23] and follows the model of *Virtual Campus* as a **virtual reconstruction** of the existing campuses and "*bricks and mortal"* buildings, i.e to "*redesign and reconfigure the human experience of existing physical spaces without having to make physical, structural changes in buildings"*. Thus, virtual spaces would complement the physical spaces when designing an effective, student centered, learning environment. A virtual campus will be a virtual learning environment that not only integrates a variety of software tools but also - all physical tools that can be found in a physical campus [10]. A (global) virtual campus should be enourmously opened towards the other stakeholders and the users and provide *virtual places* where they could meet, cooperate, communicate, and share information and knowledge. In order to meet this challenge, a GCM university could transform towards the University 2.0 Model [28] and incorporate the OER strategy [21]. Such university could also benefit from the movement of creation of e-libraries**,** e.g. global research libraries and the recently opened European portal Europeana (europeana.eu). As virtual organizations, GCM universities will adopt new form of learning: **learning through interactive visualizations and simulations** on e-infrastructures for e-science [30] and use global serious gaming environments.

One of the indicators for global reach of universities is the percentage of foreign students, PhDs and postdocs. GCM universities could promote **virtual mobility schemes**, e.g by following the Virtual Erasmus model, which complements to the existing Erasmus exchange programmes [34]. The virtual Erasmus can be used to prepare and follow-up the physical mobility or/and take courses at the home university while staying abroad. In addition, it embeds "*networked e-learning (in transnational collaboration of teachers and students) as an integrated part in mainstream higher education, aiming at transferability, scalability and sustainability: joint programme and course development, joint* *learning activities as virtual integrated elements of blended learning, 'following' (e.g. elective) courses abroad in a virtual mode*" [34]. The model of virtual mobility would be very useful for developing countries in their efforts to reduce the **brain-drain and turn it into a brain-gain** status and thus - contribute to their home countries' national growth and helping to reduce the rising "*knowledge gap*" between them and the developed countries. In order to fulfill this mission, the GCM universities should closely cooperate with international non-governmental and multi-governmental organizations.

The GCM universities should be **increasingly more research intensive** and apply scientific methods in disciplines outside the sciences in order to fulfill their third mission, i.e. for solving problems of global importance of the society as well as to have **strong orientation towards regional development and open innovation,** e.g. through participation in European and global innovation infrastructures like living labs, research intensive clusters and science parks.

Professors in a GCM university will face fast increasing global competition, especially with the development of the mixed virtual/physical mode of mobility and recruitment. In addition, they will have multiple responsibilities, i.e. not only to conduct publishable research but also to teach graduate and undergraduate students, to provide service to their universities**,** and to use their knowledge for the benefit of global, local and national communities. The use of ICT demands new skills and additional time for effective usage. The GCM universities will need a **future generations of research scientists and engineers** [25, 30] which are able to use tools and services of e-infrastructures and apply new methods to observe and to acquire data, to manipulate it, and to penetrate into new interdisciplinary areas of research reflecting the complex nature of modern science and engineering problems. The faculties must be provided with opportunities for continued professional development.

A GCM university should be an **entrepreneurial university** as well. It could adopt most of the characteristics of the Innovation University Model in Finland, e.g to become leading actor in the field of continuing education and development services provided for working life and to increase intangible capital both inside the universities and through them in society [22]. All this will shift relationships among universities and government, business, and society. On the way to a knowledge society in a dynamic ICT environment the universities should catalyse a process of **deep institutional change**. As Unsworth states, one of the major challenges facing the universities in the next decade is to **reinvent themselves as information organizations**. He emphasizes that the "*universities are, at their core, organizations that cultivate knowledge, seeking both to create knowledge and to preserve and convey knowledge, but they are remarkably inefficient and therefore ineffective in the way that they leverage their own information resources to advance that core activity*" [40]. The **model of University 2.0** naturally emerged as a framework for universities to adapt to the social computing phenomena and to the networked information economy. The University 2.0 model can be defined as *a "research and entrepreneurial university which integrates Web 2.0 technologies and applications in all university activities, including ones with all knowledge intensive stakeholders, and implements the features of the Enterprise 2.0"* [26, 28]. The Web 2.0 based virtual learning environments provide opportunities for students, professors, companies and other stakeholders to cooperate in a 24/7 fashion. The virtual space of a University 2.0 is a natural place, where the **two worlds** – the academic and the corporate ones, **could establish solid bridges and naturally integrate**, especially if the universities cooperate with Entreprise 2.0 like businesses. An extreme GCM university organizational structure could be the "*Cloudy Academy*" [20]. A GCM university could also become a *virtual organization*. Virtual Organizations (VOs) are a fast-growing phenomenon in all work settings. A VO is "*a group of individuals whose members and resources may be dispersed geographically and institutionally, yet who function as a coherent unit through the use of e-infrastructure*" [7, 30]. A VO is typically enabled by, and provides shared and often real-time access to, centralized or distributed resources, such as community specific tools, applications, data, and sensors, and experimental operations. Quite often, these resources use high-performance computing as a core capability. Such VOs are for instance EGI (egi.org) and nanoHUB.org (nanohub.org). The term VO can encompass, at least in part, systems known by other names such as collaboratories, e-science or e-research, distributed workgroups or virtual teams, virtual environments, and online research communities. VOs include a broad range of operational options, e.g they can be formal or informal, planned or unplanned, transient or long lived. They share several common characteristics [7, 30]:

- **distributed across space,** with participants spanning teritories and institutions;
- **distributed across time**, with asynchronous as well as synchronous interactions;
- **dynamic structures and processes** at every stage of their lifecycle, from initiation to termination;
- **computationally enabled**, via collaboration support systems including e-mail, teleconferencing, telepresence, awareness, social computing, group information management tools, etc.;
- **computationally enhanced** with simulations, databases, and analytic services that interact with human participants and are integral to the operation of the organization.

## 6. Conclusions

The technologies are ever changing and the new generations of Web are on the horizon – Web 3.0, Web 4.0, etc. Web technologies are increasing the intelligence of the Web and give rise of a new interdisciplinary science – Web Science [36]. Davis desfcribes these trends: *"The semantic wave embraces four stages of internet growth. The first stage, Web 1.0, was about connecting information and getting on the net. Web 2.0 is about connecting people — putting the "I" in user interface, and the "we" into Webs of social participation. The next stage, Web 3.0, is starting now. It is about representing meanings, connecting knowledge, and putting these to work in ways that make our experience of internet more relevant, useful, and enjoyable. Web 4.0 will come later. It is about connecting intelligences in a ubiquitous Web where both people and things reason and communicate together"* [9]. An emerging trend is the integration of the Web technologies with the global e-infrastructure and the academic world [35]. As we can observe a clear trend of integration of all existing forms of education, we might expect that a ultimate result of the process of transformation of education **- the whole world would become a Global Campus** in the next few decades.

## References


1. Atkins, D. et al (2003), Revolutionizing Science and Engineering Through Cyberinfrastructure, Report of the National Science Foundation on Cyberinfrastructure, NSF, January
2. Bates, T. (2001), National strategies for e-learning in post-secondary education and training, UNESCO-IIEP, Paris.
3. Bode, A., Borgeest, R., Pongratz, H. (2007), The ICT Strategy of the Technische Universität München, EUNIS 2007 "Innovation for a European ERA", June 26-29th
4. Boyer Commission (1998). Reinventing Undergraduate Education: A Blueprint of America's Research Universities, Technical Report, http://naples.cc.sunysb.edu/Pres/boyer.nsf/
5. Clark, B. (2004), Sustaining Change in Universities: Continuities in Case Studies and Concepts. Maidenhead, Berkshire, UK: The Open University Press-McGraw-Hill, 2004.
6. Clark, B. (1998), Creating Entrepreneurial Universities, organisational pathways of transformation, Oxford: Pergamon
7. Cummings, J., Finholt, T., Foster, I., Kesselman, K., Lawrence, K. (2008), Beyond Being There: A Blueprint for Advancing the Design, Development, and Evaluation of Virtual Organizations, Final Report of the Workshops on Building Effective Virtual Organizations, National Science Foundation, USA, May
8. D'Antoni, S. ed. (2006), The Virtual University. Models and Messages. Lessons from Case Studies, UNESCO-IIEP
9. Davis D. (2008), Project10X's Semantic Wave 2008 Report: Industry Roadmap to Web 3.0 & Multibillion Dollar Market Opportunities, Executive Summary, October, www.project10x.com

10. Dillenbourg, P. (2000), Virtual Learning Environments, EUN Conference 2000: “Learning in the New Millennium: Bringing New Educational Strategies for Schools”, Workshop on Virtual Learning Environments, http://tecfa.unige.ch/tecfa/publicat/dil-papers-2/Dil.7.5.18.pdf
11. EC (2010), Riding the wave. How Europe can gain from the rising tide of scientific data, Final report of the High Level Expert Group on Scientific Data, A submission to the European Commission, October 2010, http://cordis.europa.eu/fp7/ict/e-infrastructure/docs/hlg-sdi-report.pdf
12. EC (2009), e-Infrastructure, http://cordis.europa.eu/fp7/ict/e-infrastructure/
13. EC (2008), Towards a European e-Infrastructure for e-Science Digital Repositories, A report for the European Commission: "Harvesting and seeding the fruits of e-Science", http://cordis.europa.eu/fp7/ict/e-infrastructure/docs/e-scidr.pdf
14. EDUCAUSE (2008), EDUCAUSE Review, Top Ten IT Issues, vol. 43, no. 3
15. Folstad (2008), Living Labs for innovation and development of information and communication technologies: a literature review, The Electronic Journal for Virtual Organizations and Networks, Volume 10, “Special Issue on Living Labs”, August 2008.
16. Frydenberg, J., Matkin, G. (2007), Open Textbooks: Why? What? How? When?, University of California, Irvine, Distance Learning Center, The William & Flora Hewlett Foundation
17. Guri-Rosenblit, S. (2007), Higher Education in the 21st Century: Seven Pairs of Contrasting Trends, in: Enders, J., Vught, F. van (2007), Towards a cartography of higher education policy change. A Festschrift in Honour of Guy Neave, CHEPS, University of Twente
18. HECTIC (2002), European Union Policies and Strategic Change for eLearning in Universities, Report of the Project HECTIC, Coimbra Group of Universities, Brussels, April
19. Kanwar, A., Daniel, J. (2008), Knowledge Parks: Hype or Hope for the Developing World, UNESCO Int. Conference and Exhibition on Knowledge Parks, Doha, Qatar, March 29-31.
20. Katz, R. (2008). The Gathering Cloud. Is this the End of the Middle?, in: R. Katz (Ed.) (2008), The Tower and the Cloud: Higher Education in the Age of Cloud Computing, pp. 2-42, Educause
21. Koychev, I., Nikolov, R., Dicheva, D. (2009), SmartBook – the future e-book and educational hypermedia, Proceedings of National conference "Education in Information Society", May, 11-12, Plovdiv, Peter Barnev (ed), ADIS & IMI-BAS, p.30-37, ISBN 978-954-8986-30-4
22. Markkula, M., Lappalainen, P.(2008), New Openings in University-Industry Cooperation The Innovation University as the Forerunner of European University Reform, SEFI Annual Conference, Aalborg Denmark, July
23. McClintock, R. (1992), Power and Pedagogy: Transforming Education through Information Technology, Institute of Learning Technologies, New York
24. Mulder, I, Velthausz, D, & Kriens, M. (2008), The Living Labs Harmonization Cube: Communicating the Living Labs Essentials, eJOV Executive – The Electronic Journal for Virtual Organizations and Networks, Volume 10, “Special Issue on Living Labs”, November 2008
25. Nikolov, R. (2010), The Global Campus: ICT and the Global Transformation of Higher Education, Serdica Journal of Computing, Vol. 4, No. 2, pp 183-216
26. Nikolov, R (2009), The Global Campus, Avangard Print (in Bulgarian)
27. Nikolov, R. (2009), The Emerging Global Campus Model, International Conference on Computer Systems and Technologies, Ruse, 18-19 June
28. Nikolov, R. (2009), Towards University 2.0: A Space where Academic Education Meets Corporate Training, IPROF-09: ICT Professionalism: a Global Challenge, Arnhem, The Netherlands, February 12 -15

29. Nikolov, R. (2008). From eLearning to eUniversity, ACM International Conference Proceeding Series; Vol. 374, Gabrovo, Bulgaria, June 12 - 13

30. NSF (2007), Cyberinfrastructure Vision for 21st Century Discovery, National Science Foundation, Cyberinfrastructure Council, March

31. NSF (2006), NSF's Cyberinfrastructure Vision For 21st Century Discovery, NSF Cyberinfrastructure Council, Draft Version 7.1, July 20.

32. OECD (2008), Tertiary Education for the Knowledge Society, Vol.1 &Vol. 2: OECD, Paris:

33. OECD (2007), Giving Knowledge for Free: the Emergence of Open Educational Resources, OECD CERI

34. Op De Beeck, I. (2005), REVE – Real Virtual Erasmus, EuroPACE, February 2005

35. Reid, R., Edwards, P. (2009), ourSpaces - A Social Semantic Web Environment for eScience, Proceedings of the AAAI 2009 Spring Symposium on Social Semantic Web: Where Web 2.0 meets Web 3.0, 2009

36. Shneiderman, B (2007), Web Science: A Provocative Invitation to Computer Science, Communications of the ACM, Vol. 50, No. 6, June 2007, pp. 25-27

37. Smrikarov, A. (2006), The Bulgarian Virtual University – Current State and Perspectives, Nauka, Sofia, No 2.

38. Stefanov K., Nikolov R., Boytchev P., Stefanova E., Georgiev A., Koychev I., Nikolova N., Grigorov A. (2011) Emerging Models and e-Infrastructures for Teacher Education, 2011 International Conference on Information Technology Based Higher Education and Training ITHET 2011, IEEE Catalog Number: CFP11578-CDR, ISBN: 978-1-4577-1671-3.

39. Turner, P.(1995) Campus: An American Planning Tradition. MIT Press.

40. Unsworth, J. (2008), University 2.0, in: R. Katz (Ed.) (2008), The Tower and the Cloud: Higher Education in the Age of Cloud Computing, pp. 227-237, Educause.

41. Van Dusen, G. (1997). The Virtual Campus: Technology and Reform in Higher Education, ASHE-ERIC Higher Education Report 25, No. 5. Washington, DC: The George Washington University, Graduate School of Education and Human Development.

42. Weiler, H., Guri-Rosenblit, S. and Sawyerr, A. (2006). Universities as Centers of Research and Knowledge Creation: An Endangered Species? Summary Report, UNESCO, Paris.

43. World Bank (2006), Knowledge for Development Program, Capacity Building for the Knowledge Economy, http://www.worldbank.org/