Journal of Biotechnology Research
ISSN(e): 2413-3256, ISSN(p): 2413-8878
Vol. 4, Issue. 4, pp: 13-18, 2018
URL: http://arpgweb.com/?ic=journal&journal=16&info=aims

Academic Research Publishing Group

Original Research Open Access

Teaching Biotechnology: A Demand Still to be Fully Attended

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Abstract

The computer skills present an economic role for all countries both individually and politically in the current globalized world. The development of these skills requests the modernization of scholar and academic educational spaces. This modernization is necessary as it may allow better opportunities for the new generations as well as instruments to face the current social and economic challenges. However, the technology alone does not guarantee improvements in education and will depend on the pedagogical strategies of teaching and learning including the use of it as supporting and teaching tools. On that purpose, the offering of new alternatives for the elaboration and development of new methodological strategies for teaching biotechnology, a strategic worldwide area, is very important. The analysis of online tools in science education showed that they are very concentrated in the areas of basic technological science (*eg.* physics, chemistry and biology). Despite the closeness, there are few biotechnology educational initiatives for producing didactical material for teaching this subject outside the online world. Some initiatives were found pointing teaching biotechnology as an area that still has to be explored and better attended in the educational area. In this work, we brief discuss these topics to stimulate the biotechnology educational subarea to produce more process and products for teaching this theme to the society.

Keywords: Technology; Plant biotechnology; Distance education; Online tools; Multimedia applications.

1. Introduction

The potential use of technology in education in Latin America is one of the most striking issues considering the technological investment that has been made in the recent years. This investment had the purpose to improve education to meet the growing social and economic demands and change general educational statistic indexes [1, 2]. However, despite the investments made in educational technologies, there was no expressive improvement in the quality of school education regarding technology in these countries [3].

It is important to emphasize that the use of technologies reaches its highest efficacy when used as an auxiliary tool in the learning process and in a creative and conscious way, capable of developing a critical formation on those who use it [4, 5].

In this article we briefly discuss the role of technology on teaching Biotechnology, a strategic area for development in all countries, which needs specific attention as it has social and economic importance to their society. On that purpose, we used some Brazilian aspects to address this topic and to stimulate the development of the biotechnology educational subarea on producing more research about didactic material planning and distribution.

1.1. Biotechnology: Just Beginning

Modern biotechnology is an area of exploration used by man for commercial purposes, involving sectors of the economy such as human health, animal, farming, environment, industry and services. The application of knowledge

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for product generation, depend on the knowledge of basic biological processes, thereby enabling greater control and manipulation of living organisms or parts thereof, to achieve specific goals [6].

According to the Convention on Biology Diversity [7], 1992 of the United Nations cited by EPE Empresa de Pesquisa Energética [8] biotechnology is defined as any technological application that uses biological systems, living organisms, or material derived from these organisms, for the manufacture, modification (with or without improvement) of some product or process for specific use However, It has become increasingly difficult to define Biotechnology, especially due to its multidisciplinary nature, wide applicability, and evolution of biological and technological researches [8].

In 2005, in order to unify the definitions of biotechnology and to identify the different areas of applicability of this science with a better monitoring about its development in the countries of the European Community and other countries members, the Organization for Economic Co-Operation and Development (OECD) defined biotechnology as ‘’*The application of science and technology to living organisms, as well as parts, products and models thereof, to alter living or non-living materials for the production of knowledge, goods and services.’’* [9]. This definition was based on a list of biotechnology techniques in use, that involve:

• DNA (deoxyribonucleic acid) / RNA (ribonucleic acid): genomic, pharmacogenetic, gene probes, genetic engineering, DNA / RNA sequencing / amplification, gene expression profile and antisense technology.

• Proteins and other molecules: sequencing / synthesis / engineering of proteins and peptides, drug prototypes, proteomics, isolation and purification of proteins, signal transmitters, identification of cellular receptors.

• Cell and tissue culture and engineering: cell / tissue culture, engineering, hybridization, cell fusion, vaccines / immunity stimulants, embryos manipulation.

• Biotechnology of processes: fermentation in bioreactors, bioprocesses, bio leaching, bio-production of paper pulp, bio-bleaching, biodesulfurization, bioremediation and bio-filtration.

• Gene and RNA vectors: gene therapy, viral vectors.

• Nanobiotechnology: tool applications and nano/microfabrication processes to build devices for studying biosystems and drug applications, diagnostics.

• Bioinformatics: construction of databases of genomes, protein sequences and complex processes of biological modeling, including biological systems.

Among the various sectors of modern biotechnology, bioinformatics has been especially prominent in the last decades as an interdisciplinary area that addresses biological problems using computational techniques, making possible the rapid organization and analysis of biological data. Briefly, is the application of computer science (informatics) to molecular biology, which makes it possible to: (1) map sequences in databases; (2) create models of molecular interaction; (3) assess structural compatibility; (4) differentiate host DNA from pathogen DNA; And (5) to identify the motivation for conserving the protein structure [10].

1.2. The “New” School Curriculum

The classical way of transmitting knowledge, from the teacher to the student, still exists since the nineteenth century. However, the education process currently demands more and had some transformations throughout the centuries, and to this day continues to transform. Nowadays, the students need to develop the ability to use large amounts of information, transforming them into useful knowledge from day to day [3]. In order to meet these new social demands, the school curriculum needed to be adapted and reformulated, focusing on improving teacher qualification and its role as an educator in the teaching and learning process [11].

Therefore, the twentieth century was characterized by significant curricular changes worldwide. In Brazil it was created the National Education Guidelines and Bases Law (LDBEN or LDB) No. 4024/61), substituted by LDB 9.394 / 96. Several contemporary topics have been included in the curricular context, such as economic crises, social inequalities resulting from the reduction of natural spaces, aggravation of environmental problems related to physics, chemistry, biology and biotechnology [12].

Together with LDB, the Brazilian restructuration of secondary education included new teaching technologies, aiming to monitor the influence of informatics on the knowledge [13].

As an example of these new technologies, virtual learning environments can offer an important contribution and help in the teaching process, occupying a prominent place among the institutions, as facilitators and tools for teaching and learning purposes [14].

These virtual environments imprint new learning paradigms whereas propose new interactions in the educational process, becoming an important tool of inclusion of the students worldwide [15]. After several changes in LDB, now the law proposes integration of the students with the Brazilian society with help of distance learning method distance education (EAD) at state and municipal levels [16].

1.3. In the Very Beginning of EAD

The earliest records of distance education (EAD) date from the early eighteenth to the mid-nineteenth centuries in countries such as the United States (1728), Sweden (1829), United Kingdom (1840) and Germany (1856) [17, 18].

In Brazil, the earliest records of distance education (EAD) are from the twentieth century [17, 19] and its development is detached from formal education history. In its initial conception, the Brazilian EAD had the purpose to attend social and geographic needing groups, offering time, space and learning autonomy flexibilities to the student [20]. However, the official definition in Brazil was only established by Decree No. 5,622 in its article 1 in December 2005. It characterized distance education as a didactic-pedagogical modality that uses technologies information and communication helping the student to execute educational activities in different time or places [21].

Currently distance education can be composed of diverse educational means such as, open educational resources (OERs) that according to UNESCO [17] are open technological educational mechanisms for use, consultation and adaptation by a community for non-commercial purposes. These educational resources fit perfectly in public institutions since those, according to Ferreira, *et al.* [3] the natural path of education is the availability of these educational means in an open way.

In distance education interaction with educators or other students, during or after learning is the best form of interaction and the more direct and immediate, the better and more effective the academic results in order to attain the learning goals [22, 23].

However, the use of objects or learning resources in the follow-up of distance teaching must follow some requirements that according to Correa and Zuñiga [24] are: standardized identification that guarantees their use and reuse., usability, possibility of use by various learning units., interoperability or versatility of use on various platforms or systems., durability (remaining intact before the hardware and software update) and of course, the be digital.

From the point of academic view, Tamim, *et al.* [25] considers OERs as objects developed with educational and pedagogical value in addition to promoting educational innovations, since they were designed and developed by a diverse community of educators, collaborating to promote the improvement and adaptation to teaching situations. These open educational objects are stored in virtual repositories (databases available on the Internet) where these resources are indexed and made available to the public according to the author, whether for creation or recombination with other educational objects, or sharing with the academic community [25].

Some examples of foreign repositories are: Ariadne, Careo and BIOE'NR while nationally we have the Portal Teak/CRV (http://teca.cecierj.edu.br/) foundation Cecierj, Brasil, created in 2010.

This scenario marked the twentieth century as the time of the distance education implementation in Brazil whereas in the XXI century, we observed the beginning of a technological scenario full of digitized information indicating an imminent change in the way of teaching and learning [26].

This technological-information context of the XXI century has evidenced the capacity of self-learning, as an important prerequisite for this new generation of students, also requesting a greater responsibility and focused behavior for studies [27].

Technologies, especially those involving information and communication (ICT), begin to provide the ‘’construction’’ of a new citizen with an environment of sharing and interactivity [28].

Despite the autonomy profile, the student within this technological and informative environment still needs the integrated work with teacher and colleagues [29] as well as basic fundamental pedagogical strategies related to the distance process of teaching and learning to reach an efficient and successful learning process [30].

The idea of integrated education is also cited by Arogundade [1] interaction with educators or other students is one of the most effective ways to reinforce learning dynamics and encourage reflection on mistakes.

In addition, it offers advantages over the conventional method of teaching, using technologies that are easy to manipulate and that contribute to students adherence, as already occurs in clinical practice when using this type of technological teaching [31].

Supporting this idea, Gaikwad and Tankhiwale [27] reinforce that the use of multimedia applications with interactivity has the potential to increase the interest and efficiency of learning by pupils, enabling a better understanding of the basis needed for clinical practice.

Although the twenty-first century is the beginning of the increasing use of technological tools in the educational people’s and daily life, the gaps related to basic literacy skills and the low quality of basic school are still a great challenge when compared to access and dissemination of teaching technologies at schools [32]. In addition, t*he use of new methodologies in teaching is one of the basic principles of education that is to prepare the adolescent to be a citizen of a democratic and technologically advanced plural society* [33].

1.4. Virtual Environments for Learning Sciences and Biotechnology

Virtual educational environments have a wide range of possibilities for education by placing in the hand of the teacher the possibility of inserting or replacing didactic content according to the class and the rhythm of study [34]. It is possible to see this same idea in Signorini, *et al.* [2] by recognizing that virtual learning environments allow the teacher autonomy to manage the dynamics of their virtual teaching.

The use of virtual environments for science education is considered as a tool to offer inclusion of any type of students, especially when face-to-face access to the research environment is impossible or difficult due to economic or geographic reasons. This situation makes the virtual teaching environment viable and an alternative for teaching science [35]. The inclusion of computational tools is also reinforced by Miranda, *et al.* [26] that point out the use of experimental activities together with virtual environments to create a better understanding of the experiments concepts.

As for biotechnology, there are websites specially focused on teaching and disseminating this sector of science, through various types and models of educational resources, be it in text formats, videos, questionnaires, animations and simulations laboratory experiments. Thus it is becomes clear of the need for the diffusion of biotechnology in schools contributing to the student scientific and critical training [6].

Another important feature of the virtual environments is its role in EAD as an alternative space to overcome physical barriers of conventional classrooms [6]. The possibilities offered by EAD with online approach (connected to the internet network) mixed face-to-face can change the current teaching models (eg. Blended learning or hybrid learning), [36].

In addition to the modalities of Blended learning and e-learning, the mode of teaching called *flipped classroom* stands out in this scenario of possibilities, using technology as an instrument to teach. In the *flipped classroom*, the student receives the content of the discipline and learning materials before arriving in the classroom, leading to a pro-active profile.

In contrast to the traditional classroom format in which the student is a listener whereas the professor is the speaker, in the new classroom, the space is used for debates and for solutioning problems, whereas the teacher only clarifies doubts about the academic contents previously studied by the student [37].

The concept and methodology of *flipped classroom* were introduced by Lage, *et al.* [16] as an alternative and more effective method of teaching and learning when compared to the traditional learning format that does not normally consider the speed of learning and content assimilation of each individual.

1.5. Biotechnology: The Strategic Role of Teaching It to Preserve Biodiversity

Biodiversity occupies a very important place worldwide and in case of Brazilian economy, there is an international repercussion of biotechnological use of Brazil natural resources [38]. Thus, according to Cross, *et al.* [39], biodiversity is shown as a relevant source in obtaining novel compounds to be explored with the participation of modern recombinant biotechnology.

The greater value and safeness of nature-based medicines in contrast to the rigid quality control to produce new synthetic drugs point the forest as more profitable for farmers and local communities, thus providing, social and fiscal incentives for exploitation of natural resources [40].

The search for chemical components and active principles of numerous plant and animal species with some pharmacological potential, point to biotechnology and its technological resources with a strategic role in the scenario of prevention, treatment and cure of human and animal diseases. In order to further strengthen the value of Brazilian biodiversity, data published by the energy research company in its 2013 report shows that 42.4% of Brazilian energy matrix comes from renewable sources, a value well above of the world average of 13.2% showing the great appeal for its preservation [38].

So in this scenario, biotechnology fits, utilizing the knowledge of biological phenomena for the development of techniques and strategies that not only seek to respond to strictly biological issues but also, lead the basic knowledge of biology, to the more applied use of science, generating new products and services [6].

Multimedia applications can exemplify scientific applicability when generating products and services, as mentioned in Schneider, *et al.* [41] who created a computer program for urology-based diagnosis called Casuals®, resulting in an average improvement of 20% when compared to the use of textbooks for the same purpose.

In another study now conducted by Boeker, *et al.* [42], comparing the efficacy of learning the microscope to urine analysis using an e-learning-based game (using the traditional teaching method) has resulted in improved skills and knowledge cognitive group when compared to the use of texts only.

However, the development of good materials for e-learning, including multimedia, simulators or games intended for active learning, requires a highly qualified teaching staff in the technological means used, often requiring large financial investments by the educational institution [43, 44].

The previous authors argue in favor of the investment of technology teaching or renewal of teaching and more specifically of science according to Macedo [34] the reformulation of the theory taught, accompanied by a change in methodological didactics of classes through the use of updated teaching methodologies, such as those that use didactic games, strengthen the student-teacher interaction and improve the construction of knowledge.

The partnership between science and technology such as the interaction between universities and Companies, may offer the possibility of disruption of the barrier lack of appropriation of knowledge by teachers and students [45]. While Universities search for scientific knowledge construction, the companies have as main focus products and profit [46]. In addition, the creation of universities technology transfer centers has created an institutionalized and generalized mechanism to assist researchers in issues such as patenting their discoveries and obtaining fees and royalties [24].

The case specifically of biotechnology already cited by Krasilchik [23] there is difficulty in disseminating complex themes that permeate and are often transmitted in lectures and little participation presented at isolated points such as genetic transformation, approached as a topic in sciences or genetics [47].

It is in this sense that the integration of technology into educational practices within the university, promotes a redefinition of the university concept [25]. Similar thoughts can be found in Castells [48] because the contemporary concept of what is a university is losing the status of an autonomous center of production, preservation, and transmission of knowledge, and instead, a sociocultural vision is born in which the university is only a knot in a global sustainable network–construction.

Thus, the important contribution those virtual teaching environments can offer helping on teaching Biotechnology leading to the improvement and dissemination of biotechnological scientific knowledge to the society at very early age but also to the adults.

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