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DISTANCE LEARNING IN THE THEME NANOSCIENCE AND NANOTECHNOLOGY APPLIED TO HEALTH AREA

Perspectives and Interprofessionalism

JACKELINE NERES BELLUCCI[1], FELIPE SILVA BELLUCCI[2], GILBERTO LACERDA SANTOS[1]

[1] Universidade de Brasília (UnB), Brazil
[2] Ministry of Science, Technology and Innovation of Brazil, Brazil

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ABSTRACT

Teaching by means of distance learning has grown rapidly in the last few years, allowing Brazilians access to improved higher education in their own country. However, certain challenges exist when it comes to teaching complex, contemporary issues such as Nanoscience and Nanotechnology (N&N). A certain amount of reflection is still required. The objective of this paper is to analyse teaching methods used in distance learning in the fields of N&N which are applied in the areas of health science, with special emphasis on potential, strengths, and peculiarities. Issues such as; (i) collaborative learning and (ii) difficulties and opportunities of using distance learning in N&N, among other topics, are presented and discussed. The results indicate the potential use of distance learning in this field of study. Special attention is devoted to the multidisciplinarity and interprofessionalism of the subject as well as to the heterogeneous background of the students and the high level of abstraction.

GLOBAL KNOWLEDGE ACADEMICS

1. Introduction

Distance Education Modality (EAD) (Simonson, Smaldino, Albright & Zvacek, 2000) is a teaching practice that has become more and more popular, as well as consolidated in several areas of modern society in the recent past, mainly due to the popularization of media such as the Internet. Conceptually, distance education is the process of teaching and learning, mediated by Information and Communication Technologies (ICT), in which teachers and students are separated spatially and/or temporarily, but can be interconnected by technologies, especially telematics, like the Internet (Kennedy, Laurillard, Horan, & Charlton, 2015; Sosa & Manzuoli, 2019). The Institute of Applied Economic Research (Ipea), with the purpose of disseminating the "possibilities and megatrends of the future", presented Brazilian society with a set of megatrends and seeds for the future. The main axes identified were: population and society, geopolitics, science and technology, economics and the environment. In the population and society axis, the profile of Brazilian society stands out. In Brazil, with an aging population, an increase in the middle classes and a greater desire for schooling, EAD has emerged as a great option for the masses due to its low cost. It flourishes not only in a fertile environment of Z individuals, born-digital natives since 2000 but also at a time when Internet access has become widespread throughout Brazil (Marcial, 2015).

Some of the main advantages of this modality of education are the flexibility of time and place of learning, the elimination of the time taken to travel to traditional places of teaching and the increase in the number of students per class. In the case of distance education, the learning process is mainly designed by the student himself; that is, he becomes the main actor of knowledge, and for this, he relies on the teacher as the mediator of this process, making learning effective. However, major challenges are still in the process of being overcome - such as improving teaching methodologies, evaluating the teaching-learning process, and especially the massive extension of this modality of education to more complex areas, for example; Health Sciences, Nanoscience and Nanotechnology and their interfaces (de Souza Alves, Bohomol, & Cunha, 2015) (McNew, Gordon, Weiner, & Trangenstein, 2016; Blankenship, Abell, Main, Elaine, & Vickous, 2019).

Nanoscience and Nanotechnology (N&N) are emerging, multidisciplinary and interdisciplinary areas for the study and application of dimensional scale materials of the order of nanometers (1x10-9 m) (Mulvaney, 2015). Specifically, Nanoscience studies the phenomena and their influence on the properties of materials at the nanoscale, while Nanotechnology explores the resulting knowledge of Nanoscience to create structures, devices, and systems that exhibit new properties and functions due to the dimensional scale used (Feynman, 1960). N&N studies are enabling great scientific advances and new ways of understanding and creating materials, devices, and systems. New generations of materials are under development and improvement, such as nanoparticles, thin films and nanocomposites with applications in the areas of electronics, telecommunications, computer science and biotechnology. Applications of these materials in research in the areas of life sciences, particularly at a cellular level, define a new technological trajectory and new actors for biotechnology (Shrivastava & Dash, 2009). Biological systems, such as cells, are complex, highly functional and specific systems composed of macromolecules that are involved in virtually all cellular processes, such as information transfer, metabolism, and substance transport. Thus, due to the dimensional compatibility between biological systems and nanometric structures, Nanotechnology offers a new set of tools capable of interacting with biological systems, opening a wide spectrum of possibilities of action (Bellucci, 2009).

As an example of the potential of nanoscience and nanotechnology applied to health sciences, health professionals have the possibility of analyzing their patients' molecular profiles and recommending specific and personalized treatments for complex diseases such as neoplasties and diabetes (Curtis, 2001). Scientific studies have shown the advantages of using molecular profiles to identify specific tumor

targets (Berkowitz & Goddard, 2009). Thus, it is important that health professionals become familiar with concepts such as drug-delivery treatment, hyperthermia actions in neoplasties using magnetic nanoparticles, nanobiosensors for monitoring and rapid diagnosis, among others, so that they can present their patients with new treatment options and provide active health care (Serena, Martin Gago, Casero, & Briones, 2008). However, analyzes, reflections, evaluations, and discussions about the teaching of contemporary, multidisciplinary and interprofessional topics, in particular, the concepts and applications of N&N to health sciences, in the distance mode, are still scarce in the scientific literature.

This multidisciplinary study had as its main objective to present an analysis of the possibility and potentiality of the use of the distance education modality for complex and interprofessional subjects, specifically, Nanoscience and Nanotechnology applied to the health sciences. Elements such as collaborative learning, N&N interfaces in the areas of health sciences, strengths and attention points were investigated and discussed.

2. Methodological Approach

It is research of a Bibliographic Review with qualitative and descriptive-analytical characteristics that according to Lakatos and Marconi (2007), implies in indirect data collection through consolidated sources such as periodicals/journals, scientific articles, dissertations, and theses, so that the researcher has access to the current state of the art related to the proposed theme, being able to raise new questions, reflections and new approaches within research which have already been carried out.

Scientific Repositories: The study of the current state of the art presented in this work was carried out in the Capes database, using the bibliographic sources obtained in the following scientific libraries: (i) Web Of Science; (ii) SciELO; (iii) MEDLINE; (iv) Biblioteca Virtual em Saúde (BVS); (v) Literatura Latino-Americana e do Caribe em Ciências da Saúde (LILACS); (vi) OCHRANE; and (vii) PubMed.

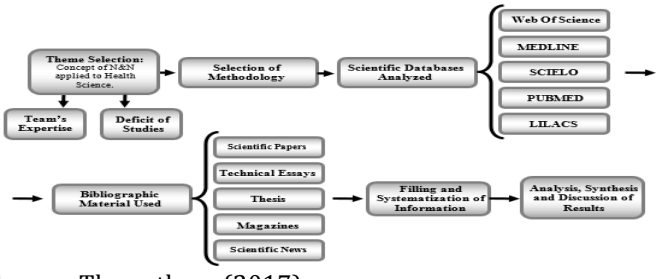
Descriptors Used: The descriptors were selected aiming at the highest agreement research/scope of the study, being: (i) Distance Learning Modality; (ii) Education of Nanoscience; (iii) Education of Nanotechnology; (iv) Applications in Health Sciences; and (v) Interprofessional Health Education.

Bibliographic Statistics: For the composition of this study, a total of 34 scientific pieces of work (scientific articles from national and international journals, reports from specialized agencies, theses, and dissertations) were selected and analyzed.

Selection Criteria: The bibliographic material found was selected according to the following criteria: (i) relevance of theme and content; (ii) technical quality of the research; (iii) current bibliographic material; (iv) method and reliability of results; and (v) research findings. The criteria that did not include those of inclusion were excluded.

Systematization of Information: The bibliographic material selected was archived according to the norms of archiveology, aiming at the organization, conservation, and systematization of the information. During the filing, information such as the main idea, scientific contribution contributed by the study, authors, method, reliability of the results and conclusions of the research were evidenced and correlated.

Figure 1.
Shows an organization chart that systematizes the main steps of the study on the use of the EAD modality for subjects such as N&N applied to Health.



Source: The authors (2017).

3. Research Aspects

The use of new technologies and the model of open education to provide knowledge are currently frontiers for modern society. In this

scope, EAD teaching actions have attracted the attention of the academy in order to improve its teaching and assessment tools, as well as the approach of complex and contemporary themes such as the N & N and its interfaces with the Health Sciences.

3.1. Technology-Driven Technology Actions: Distance Education

3.1.1. Evolution of the Use of Distance Education

Information and Communication Technologies (ICT), incorporated into EAD, can act in a more meaningful way in the teaching-learning process, promoting important contributions in pedagogical planning and mediation applied to distance learning actions. Thus, more and more, educational managers perceive the importance of ICT in the process of obtaining knowledge, as they provide a new way of communicating. Students are able to relate, exchange information and experiences and teachers and/or tutors can carry out work in groups, debates, forums, among others. In this understanding, studies show that technological tools provide education without geographical barriers, freer in time, more inclusive and multisensorial, enabling the education system to assume a role of training citizens more efficiently, providing more effective resources to attend and motivate the actors involved in the teaching-learning process (Otani et al., 2016).

In the area of health, EAD initiatives for training and professional qualifications are being gradually instituted, in a country that experiences a situation of great regional diversity in relation to socioeconomic conditions and access to information. It is also recorded that studies have described a more positive view by health professionals regarding the use of the EAD modality, facilitated by technological advances and access to a computer and the Internet. More specifically in relation to nursing professionals, EAD has begun to be seen as an educational tool capable of improving the professional qualifications of this area. Faced with this reality, EAD is considered as a relevant teaching-learning modality, capable of complementing the regular system of presidential teaching based on current pedagogical practices and technological resources that facilitate communication and interaction between teacher and student, beyond limits of time and distance, facilitating access and equity (McNew, Gordon, Weiner, & Trangenstein, 2016).

The distance courses segment is now being favored by great institutions due to the low cost for those who offer the courses and for the student too. According to the Brazilian Ministry of Education (MEC), the model went from a slice of 0.8% of the private market in 2004 to 20.5% in 2014. In 2016, it was estimated that this index was close to 30%, according to the consultancy Hoper Education, mainly due to reductions in government funding, such as the FIES (Educational Financing Fund), for face-to-face teaching (Cunha, 2016). Figure 2 and Table 1 show the percentage distribution of students enrolled in private higher education in face-to-face and distance education between 2004 and 2014 in Brazil.

Figure 2.
Shows the percentage distribution of students enrolled in private higher education in face-to-face and distance education modalities, between 2004 and 2014, in Brazil.

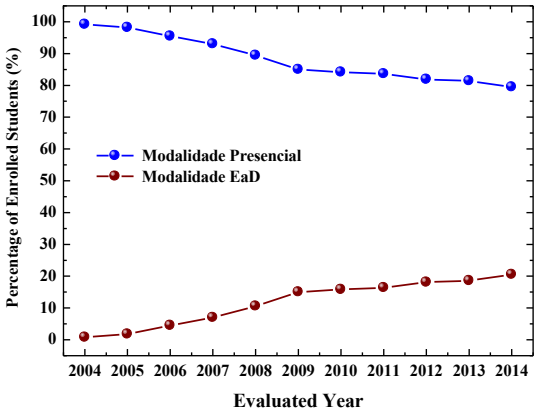


Table 1.
Percentage of students enrolled in private higher education in face-to-face and distance education modalities, between 2004 and 2014, In Brazil

Teaching Modality	Evaluated Year										
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Face to face (%)	99.2	98.2	95.5	93.0	89.4	85.0	84.2	83.6	81.9	81.4	79.5
Distance Education (%)	0.8	1.8	4.5	7.0	10.6	15.0	15.8	16.4	18.1	18.6	20.5

Source: The authors (2017).

Undergraduate and postgraduate teaching practices in the areas of exact sciences and health generally address the fundamental themes of each area for the quality training of future professionals (Pinto, Marin, Tonhom, & Ferreira, 2016). It is up to the university to provide, through courses of extension and scientific research, a selection of applied knowledge that complements and generates a differential for the training of the students. Recent studies have shown that a large number of higher education institutions have implemented the EAD modality in their curricula to meet the demands of a new educational market. With the development of teaching and evaluation methodologies in the EAD, the opportunity has been opened to technically address more complex issues such as neurosciences, law theories, less popular engineering courses, and N&N.

3.1.2. Collaborative learning: Virtual Learning Environment (AVA)

One of the main potentialities of EAD teaching is the collective construction of knowledge, in which the concepts are constructed by the sum of the contributions of each student. Collaborative learning is facilitated by the functionalities and tools present in the AVA, a specially planned virtual space where EAD actions are performed. The organization of the virtual environment allows the student to carry out organized and systematic monitoring of what is studied in each period of time. Currently, there are several platforms that have been specially designed to foster collaborative learning. Some of them are highlighted below:

(i) Moodle (Modular Object-Oriented Dynamic Learning Environment): Moodle is a free software-based distance learning platform, as well as a consecrated system, with one of the largest user bases in the world, with more than 25 thousand installations, more than 360 thousand courses and more than 4 million students in 155 countries;

(ii) Platform Learning is an AVA built using the Moodle platform, version 2.7, and designed to support teachers and students in teaching and learning activities in the disciplines and courses of UnB, facilitating the interaction between students, teachers, tutors and monitors involved in this process;

(iii) MOOCs (Massive Open Online Courses) are teaching actions offered through AVA, Web 2.0 tools or social networks designed to offer opportunities to continue education to a large number of students, as well as open access, scalability and connectivity. A number of projects associated with MOOC have emerged independently, such as Coursera, Udacity, OpenClass e edX;

In this context, AVA foster active student participation in the learning process, promote the mediation of learning by teachers and tutors and stimulate the collective construction of knowledge through the exchange of knowledge and experiences among peers.

3.2. Nanoscience and Nanotechnology Applied to Health Sciences

3.2.1. As future areas, N&N has been gaining prominence year by year in the area of Health Sciences due to its innovative character. The following items present a set of reflections on the applications of Nanotechnology in the area of Health Sciences.

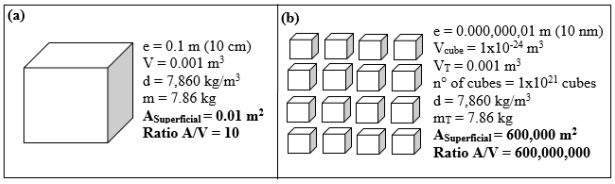
3.2.2. General Aspects of Nanoscience and Nanotechnology

During the annual meeting of the American Physical Society (APS), in 1959, held in the renewed California Institute of Technology (Caltech), the North American physicist Richard Philips Feymann gave a visionary lecture, presently considered the initial point of Nanoscience and Nanotechnology. In this lecture named "There´s plenty of room at the bottom", Feynman presented a set of new ideas and reflections on various topics of knowledge, among them, the possibility of control and manipulation of matter on an atomic scale. In short, the physicist defended the hypothesis that there was no theoretical obstacle or violation of physical laws for the control and manipulation of matter on an atomic level, and consequently, there were no theoretical impediments to the construction of devices composed of atoms, molecules or structures on the atomic scale. Thus, for Feynman, it was only a matter of time before society could develop methods for observing and acting on the matter on an atomic scale (Novo, 2016).

The N&N are emerging, multidisciplinary and interprofessional areas for the study and application of materials with a scale of the order of nanometers (1x10-9 m), which have emerged in recent decades and are therefore relatively recent areas in the history of science. The prefix 'nano' refers to a measure that means a billionth of the meter, that is, it is like dividing a meter into a billion pieces. From a scientific point of view, investigating the properties of matter at nanoscale implies conducting a multi-concept analysis of the nature of matter, using concepts from Chemistry, Engineering, Physics, Biology, and others. This particularity gives N&N a multidisciplinary character. Since the development of the first electronic microscopes in the late 1970s, N&N has been included in the strategic agenda of Science, Technology and Innovation of the main countries of the world and is considered as the new knowledge revolution. Such topics already have concrete applications in areas such as; aerospace, agribusiness, defense, energy, environment, devices and sensors, diagnostic systems, health and textile industry (Specia, R Z, Ramos, G C D, López, 2016).

Origin of the difference between macro and nanoscale: As a simple example of how the properties of matter can be modulated with the change of the dimensional scale, Figure 3 (a) shows a cube of iron [density (d) = 7,860 Kg/m3] with an edge (e) equal to 10 cm (0.01m) while Figure 3 (b) shows the same cube, divided into smaller cubes with an edge equal to 10 nm (0.000,000,001 m).

Figure 3.
Comparison between the geometric parameter of a cube with edge equal to 10 cm and its respective fragmentation in nanometric cubes with edge equal to 10 nm, in order to evidence the difference between macro and nanoscales



In accordance with Fig. 3, with the division of the initial cube, the total mass (m) and volume (V) remain the same, however, it has generated 1x1021 smaller cubes conferring a new superficial area (A) equal to 600,000 m2 to the material. In this sense, the ratio “surface area to volume” is of a cube changes from 10 to 600,000,000. After the geometric changes in the material, especially the size of the edge, surface area and A/V ratio, the system interacts differently with the neighborhood mainly due to: (i) with reduced overall size, the material will be able to interact with new dimensionally compatible structures such as biological agents like cells, viruses, bacteria, and others; (ii) with the increase of the contact surface, the surface activity of the material increases, making it more reactive; (iii) with the increase of the area/volume ratio, the material exhibits properties predominantly of the surface and not of the properties of the material volume; and (iv) with the reduction of the size of the material repetition unit, it begins to interact with different external physical agents such as light and atmosphere.

3.2.3. Nanoscience and Nanotechnology Applied to Health Sciences and Nursing

N&N Modality is no longer a part of the role of technological promises and potential scientific applications to integrate the real technological applications framework with products made available to society, characterizing the transfer of knowledge to the productive sector, as well as generating economic value for society. Several new nano-based functionalities can be added to products already available in the market and new nanotechnology-based products can be launched in the market in many economic sectors, such as textiles, cosmetics, energy, electronics, environmental, agriculture and, as may be expected, health sciences (Mulvaney, 2015).

In Health Sciences, a set of technologies developed in the areas of drugs and administration of drugs, cosmetics, portable systems for complex diagnoses in a quicker and more accurate way, among others, already exist. In this sense, examples of nanotechnological applications for Health Sciences, with an advanced stage of development and the possibility of great direct impacts on the quality of life of the population, are listed below:

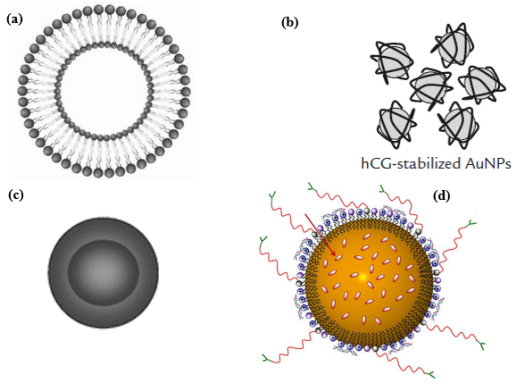
(i) Nano-encapsulated antimalarial drug: Even with current scientific and technological development, neglected diseases, such as malaria, are health problems yet to be addressed. The artemisinin-derived antimalarial artemether was encapsulated in liposomes (see Fig. 4 (a)) for in vivo tests, utilizing male New Zealand white rabbits. The results showed significant increases, from approximately 32% to 98%, in the bioavailability of the drug when administered orally (Bayomi, Al-Angary, Al-Meshal, & Al-Dardiri, 1998; Pimentel, Jácome Júnior, Mosqueira, & Santos-Magalhães, 2007).

(ii) Gold nanoparticles used in pregnancy tests: Pregnancy tests performed on urine are widely used diagnosis due to their ease and low cost. This kind of pregnancy test is based on the principle of immunochromatography and gold nanoparticles can be used for this purpose. Antibodies that react in the presence of hCG hormone (human chorionic gonadotropin) are enhanced when they are covered by gold nanoparticles (see Fig. 4 (b)). This system can make pregnancy testing cheaper, faster, more sensitive and accurate (Patent No. US 9,360,431 B2, 2016).

(iii) Polymeric Nanoparticles as Breast Cancer Drug Carriers: Polymer nanoparticles represent a technological solution capable of aggregating excellent biocompatibility, non-immunogenic and non-toxic response, as well as being biodegradable. The bioactive agent paclitaxel was efficiently nano encapsulated in albumin nanoparticles for the treatment of breast cancer. One of the main advantages of this use is that the drug becomes effective in a shorter period of time, together with the vectorization of the drug to the tumor tissue (see Fig. 4 (c)) (Dimer, Friedrich, Beck, Guterres, & Pohlmann, 2013).

(iv) Nanometric markers for diagnosis and treatment of diseases: Techniques that use nanoparticles coated with markers for identification and therapy of diseases, especially oncology, can be used inside the body (in vivo), which can be divided into two categories: diagnostic (magnetic resonance imaging) or therapeutic (cell marking, vectorization of drugs and magnetic hyperthermia); or outside the body (in vitro), mainly for diagnosis (separation and selection) (see Fig. 4 (d)) (Falleiros, Brandl, & Fonseca, 2011)

Figure 4
Illustrative representation: (a) transversal cut of a liposome; (b) Gold Nanoparticles recovered by hCG hormone; (c) Polymeric nanoparticles in which active agent is conjugated or encapsulated in a polymer; and (d) Nanoparticles recovered with markers to diagnosis or treatment of diseases, in special, to oncology.



Furthermore, when it comes to human health, Nanoscience and Nanotechnology have enabled the creation and transformation of a wide variety of products and services that can add value and knowledge to clinical practice and public health. In this sense, the use of N&N is mainly focused on diagnosis, therapy and disease prevention, the understanding of biological mechanisms and the development of cosmetic and cosmeceutical products. In Brazil, the main areas of research are; synthesis and characterization of new advanced nanomaterials, pharmaceutical, cosmetics and cosmeceutical, and agribusiness.

In the last few years, among the strategies for development of Science, Technology, and Innovation (S, T&I), Nanoscience and Nanotechnology have stood out for their innovative technology due to their transversal nature, which allows them to make an impact on large economic sectors that demand technological and innovative developments. Data from the Organization for Economic Co-operation and Development (OECD, 2017), specifically, the OECD Key Nanotech Indicators, show that there are over 12 thousand companies all over the world that use nanotechnology to carry out services and/or to perform research. According to data from the Brazilian Innovation Survey (Pesquisa de Inovação - PINTEC) managed by the Brazilian Institute of Geography and Statistics (IBGE), 975 innovative companies develop this kind of activity for nanotechnology in Brazil (IBGE, 2016).

3.3. Analysis of the Potentiality of the Use of Actions in the EAD Mode for the Teaching of Nanoscience and Nanotechnology Applied to Health Sciences

Technology-mediated teaching actions open up a new range of possibilities that include open learning, (mass) scalability, and the approach to complex, specific subjects such as N & N applied to Health Sciences.

- General Considerations for the Interface between the EAD Mode and the N&N
- N&N consolidates rapid development dynamics and diversified applications across virtually every industry. N&N are already realities observed in numerous products marketed by different sectors, such as in the areas of health science, electronics, telecommunications, computing, and life sciences. Applications of these materials in research in the areas of life sciences are mainly focused on diagnosis, therapy and disease prevention, understanding the biological mechanisms and the development of cosmetic and cosmeceutical products. In this sense, at the same time that Nanotechnology revolutionizes society by introducing new products and processes, it demands more specific methods of dissemination capable of approaching knowledge in a multidisciplinary and interprofessional way, attaining diverse extracts from academic and professional societies, as well as displaying a constant updating capability, since new discoveries and applications are to be found in this area (Rita, Figueiras, Coimbra, José &Veigas, 2014).
- Educational practices in the partial mode and totally at a distance are unequivocally presented as a tendency to massify access to formal education, continuing professional education, professional updating, as well as mass access to knowledge, regardless of geographic location. Limitations that were very clear and evident, such as reduced evaluative processes and lack of control over the commitment of teachers and students, have been significantly reduced in recent years. Cultural resistance when mediation of the teaching-learning process through technological resources has been overcome by teachers, students, and educational managers. The development of new, more efficient technological tools and a greater understanding of the EAD teaching-learning process has made it possible to approach more complex and abstract subjects such as anatomy, engineering, economics, technology and scientific innovation (Rush, 2015).

- The use of teaching strategies based on the EAD modality for N&N directed at Health Sciences exhibits a set of particularities that favours the efficiency of teaching. Among these particularities, the possibility of massively offering the subject to health professionals can be highlighted, as an option for continuing education, potential to approach this subject in a multidisciplinary and interprofessional way, offering a list of optional and complementary knowledge that facilitates the understanding of the content and enables the use of technological tools, such as interactive videos and computer simulations, to facilitate the understanding of abstract themes. In this sense, the use of didactic strategies in the partial or total distance modality exhibits the potential to address complex technological themes such as Nanoscience and Nanotechnology and its applications in several areas of knowledge (Ellwanger, Rossato, Granada, Bortoluzzi, & Fagan, 2012).
- Intrinsic Characteristics of Distance Education in Teaching Nanoscience and Nanotechnology

Due to their intrinsic characteristics, both partial and total distance teaching practices are promising for the approach to the topic of Nanoscience and Nanotechnology and its interface with Health Sciences. The main strengths that justify the potentiality of addressing N&N themes are listed below.

a. Facilitator of Complementary Knowledge: Due to the inherent multidisciplinarity and interprofessionality of the subjects of Nanoscience and Nanotechnology, it is necessary to possess the basic mastery of concepts in several areas of knowledge - Chemistry, Physics, Mathematics, and Biology - to understand N & N concepts as well as their potential for a technological revolution. In this sense, AVA facilitates the availability of complementary knowledge in the main correlated areas, which can be accessed by the student, as doubts or difficulties arise (Santos & Rosa, 2016);

b. **Flexible Teaching and Continuing Education Actions:** Since the subject of N&N is not a compulsory part of the health sciences courses/curricula established by the Brazilian Ministry of Education (MEC), the National Education Plan (PNE), this can be embedded in the actions of continuous training, improvement, and updating of health professionals. In this sense, fully EAD initiatives are interesting because they are temporally flexible, exhibit low cost per capita, have no geographical limitations, can offer a large number of employment opportunities, among others (Otsuka, Oliveira, Lima, Mill, & Magri, 2011);

c. Multimedia Environment as a Learning Facilitator: The nanometer scale (1x10-9 m) and the phenomena of matter on this scale present a set of specificities that cannot always be well represented by our cognitive senses and conceptual subsumes. In order to facilitate the correlation, visualization, and learning of the concepts of Nanoscience and Nanotechnology and their interfaces with health sciences, it is necessary to use different media, videos, audios, websites, interactive actions, simulations, organizational charts, dynamic student interactions - student and student-tutor, among others. In this context, teaching practices in the distance modality are intrinsically conducive environments for the use of multimedia/multimedia activities that facilitate the teaching-learning process and meaningful learning (Otsuka, Oliveira, Lima, Mill, & Magri, 2011).

As is the case in various educational activities, teaching actions in the EAD partial or total modality, intrinsically present barriers to be overcome by the individual, thus representing the known challenges of this modality. These points can be maximized or minimized when the object of the educational activity is complex and contemporary, such as in the case of Nanoscience

and Nanotechnology applied to Health Sciences. Below are some of the main challenges to overcome in N&N in EAD (Santos & Rosa, 2016);

i. **Shortage of Specific N & N Content for EaD:** The lack of availability of teaching-learning theories focused specifically on the EAD modality, specific teaching methodologies for EAD, diversity of effective monitoring and evaluation processes, among others, is still a point of attention in the field of EAD. This point is even more latent when the themes to be taught are complex and contemporary, such as the N&N applied to the Health Sciences. Currently, there is no abundance of contents available on this subject (Ellwanger, Rossato, Granada, Bortoluzzi, & Fagan, 2012).

ii. **Language Barrier and Low Availability of Specialized Manpower:** Because it is a relatively new topic, at the forefront and frontier of knowledge, as well as being in wide world expansion, the overwhelming part of the bibliography available on N&N is in the English language, and the quantitative of skilled labour in this area is still being consolidated in Brazil. These factors directly reflect the teaching methods of the subject in the EAD modality, since they restrict the availability and access to border contents for the general public and the supply of N&N skilled labour to work in its teaching (Afonso, 2011).

iii. **Cultural Alteration of Learning and Educational Maturity:** When using the mode of partially or totally distance teaching, there is a displacement of the protagonism of the teacher to the student. This shift is also associated with the student's cultural shift in posture, moving from a predominantly passive posture to a more active posture. To overcome this change in posture, the student is expected to exhibit a minimum educational maturity related to the difficulties encountered in learning, lack of discipline and student organization. In the N&N approach using EAD routines, cultural change factors and educational maturity are even more challenging due to the complexity of the topic and the need for the search of extra knowledge and correlation (Santos & Rosa, 2016).

Difficulties and Opportunities of N&N Teaching EaD

Teaching practices in the EAD modality have grown considerably in terms of expressiveness, quality, and dynamism. In this sense, due to the natural process of development of this modality of teaching, there is a set of tools and characteristics that already exhibit good acceptance, but other tools and characteristics have not yet been exhaustively discussed in the necessary depth.

The main positive points indicated, such as those that support the use of the EAD modality in the teaching of "Nanoscience and Nanotechnology Applied to Health Sciences", are listed below: (i) the flexibility of the course schedule, which allows students and health professionals to always complete the curriculum and to be recycled; (ii) the ease of adjusting the theme with the EAD methodology contributes to the development and improvement of Health Science areas; (iii) new technical-scientific contributions to the interface of the above-mentioned themes; (iv) diffusion of both areas and their interface; (v) development of more effective and attractive methodologies, systematic and conclusive information for the area of EAD applied to Health Sciences; (vi) production and application of quality teaching materials capable of broadening the knowledge spectrum of students and health professionals and encouraging them to maintain continuous training; (vii) development of a final product that can be characterized as a technological product that can be protected intellectually; (viii) broader, more solid, multidisciplinary, interprofessional and comprehensive training of students and professionals in the areas of health sciences; (ix) more complete and broad training in the topic of high technology applied to the subject; and (x) low cost per student (Souza, Iglesias, & Pazin-Filho, 2014).

The main points that have not yet been exhaustively discussed and which call for reflections and improvements in the use of the EAD in the teaching of "Nanoscience and Nanotechnology Applied to Health Sciences" are

indicated below: (i) the aforementioned subject could be solved more constructively if experimental classes and field lessons were used, but unfortunately such types of interventions are not yet possible in fully EAD courses; (ii) the culture of classroom use is still very much rooted in teaching methodologies; (iii) the EAD methodologies are still unattractive to the health area; (iv) the diversity of training in the area of health sciences makes it difficult to develop a methodology that is attractive to everyone; (v) assessment processes need to be improved to become more effective and able to determine whether the student is actually learning; (vi) the current scenario has undergone transformation and the traditional values are continuous changing, however teaching's strategy often remain supported in a traditional education; (vii) there are areas of the country that do not provide access to the Internet and/or the necessary computer infrastructure; (viii) low interaction in the EAD environment between apprentices and tutors; and (ix) the difficulty of the sutents being the protagonist of their formation thenself (Souza, Iglesias, & Pazin-Filho, 2014).

In order to combat the main negative points, it is suggested that the semi-presidential methodologies are used more, in which the classroom part is destined to discuss in a summarized way the main points of the subject in question, experimental classes and activities in the field. In the non-presidential part of the course, the more specific discussions, the case studies and the complementary readings could be foreseen using the classic tools of virtual platforms such as a forum or a collective chat. From the point of view of social relevance, studies and research in teaching in the EAD modality will provide advances in the reflections and foundations of the potential use of this modality of education in continuous training and dissemination of the technical knowledge in the area of health sciences. Thus, despite the challenges, EAD is believed to be a teaching-learning modality with new perspectives for the health area (Kakushi & Évora, 2016).

4. Conclusions

The popularization and diffusion of digital technology in recent years has significantly transformed society as well as providing changes in individuals' personal and professional lives. In this context, according to the Census of Higher Education of 2016 of the Ministry of Education, enrollments in tertiary education in the semi-distance or full distance modality already correspond to more than 18% of enrollments in Brazilian higher education. Due to its strengths, such as temporary flexibility, low per capita cost, absence of geographical limitations, the possibility of offering a large number of job opportunities, among others, the EAD has been increasing its insertion in society and complementing the form of learning and access to knowledge. Current issues, multidisciplinary, interprofessional and complex ones such as N&N, began to be diffused through these teaching practices. The main strengths that justify the potentiality of addressing N&N themes through full-teaching teaching practices are; (i) Facilitator of Complementary Knowledge; (ii) Flexible Teaching and Continuing Education Practices; and (iii) Multimedia Environment as a Learning Facilitator. Just as in other educational activities, the practices of teaching EAD, either partially or totally, intrinsically present barriers to be overcome by the individual, thus representing the known weaknesses of this modality. Some of the main challenges to be overcome in this area are listed below: (i) Scarcity of specific N&N content to EAD; (ii) Language barrier and low availability of skilled labour; and (iii) Cultural alteration of learning and educational maturity. It should be emphasized that there are relatively few studies on the best ways for N&N teaching and diffusion applied to Health Sciences using virtual teaching environments. The main results point to the possibility of using the EAD modality as an innovative way of diffusing potentialities in N&N, massive achievement and continuous training of interprofessional human resources in health.

References

Alfonso, A. B. (2011). Situação atual da divulgação e do treinamento em nanociência e nanotecnología no Brasil. Mundo Nano. *Revista Interdisciplinaria en Nanociencias y Nanotecnologia,* 4(2). Retrieved from http://www.revistas.unam.mx/index.php/nano/article/view/44966

Bayomi, M. A., Al-Angary, A. A., Al-Meshal, M. A., & Al-Dardiri, M. M. (1998). In vivo evaluation of arteether liposomes. *International Journal of Pharmaceutics*, 175(1), 1–7. https://doi.org/10.1016/S0378-5173(98)00182-3

Bellucci, F. S. (2009). Caracterização Dielétrica de Partículas Nanométricas e Nanoestruturadas de Óxido de Niobato da Família Tetragonal Tungstênio Bronze com Estequiometria K'Sr IND. 2' N'b IND. 5' 'O IND. 15'. Universidade Estadual Paulista, 2009. 156 f. Dissertação (mestrado). http://hdl.handle.net/11449/88464

Berkowitz, A. C., & Goddard, D. M. (2009). Novel Drug Delivery Systems: Future Directions. *Journal of Neuroscience Nursing,* 41(2). Retrieved from https://journals.lww.com/jnnonline/Fulltext/2009/04000/Novel_Drug_Delivery_Systems__Future_Directions.8.aspx

Blankenship, M. M., Abell, C. H., Main, M. E., Elaine, K., & Vickous, Y. (2019). Nursing Alumni : Continuing Education Preferences. 5(1).

Cunha, J. (2016). Acordo entre Estácio e Kroton vai movimentar educação a distância. Retrieved from http://folha.com/no1790728

Curtis, A. (2001). Nanotechniques and Approaches in Biotechnology. *Trends Biotechnol,* 19(3), 97–101. https://doi.org/10.1016/S1369-7021(01)80035-3

de Souza Alves, V. L., Bohomol, E., & Cunha, I. C. K. O. (2015). Educação de pós-graduação em enfermagem à distância: avaliação sob a perspectiva dos discentes. *ACTA Paulista de Enfermagem*, 28(2), 139–145. https://doi.org/10.1590/1982-0194201500024

Dimer, F. A., Friedrich, R. B., Beck, R. C. R., Guterres, S. S., & Pohlmann, A. R. (2013). Impact of nanotechnology on public health: Production of medicines. *Quimica Nova,* 36(10), 1520–1526. https://doi.org/10.1590/S0100-40422013001000007

Ellwanger, A. L., Rossato, J., Granada, M., Bortoluzzi, V. I., & Fagan, S. B. (2012). O Ensino De Nanociências Por Meio De Objetos De Aprendizagem. *Renote*, 10(1), 1–10. https://doi.org/10.22456/1679-1916.30884

Falleiros, J. P. B., Brandl, A. L., & Fonseca, A. R. A. da. (2011). Aplicações da nanotecnologia no diagnóstico e tratamento de câncer. *Nucleus*, 8(1), 151–169. https://doi.org/10.3738/1982.2278.453

Feynman, R. P. (1960). There's plenty of room at the bottom. *There's Plenty of Room at the Bottom,* 23(5).

Kakushi, L. E., & Évora, Y. D. M. (2016). As redes sociais na educação em enfermagem: Revisão integrativa da literatura. *Revista Latino-Americana de Enfermagem*, 24. https://doi.org/10.1590/1518-8345.1055.2709

Kato, Y., Ito, D., Kitani, Y. (2016). Patent No. US 9,360,431 B2. The United States.

Kennedy, E., Laurillard, D., Horan, B., & Charlton, P. (2015). Making meaningful decisions about time, workload and pedagogy in the digital age: the Course Resource Appraisal Model. *Distance Education,* 36(2), 177–195. https://doi.org/10.1080/01587919.2015.1055920

Lakatos, E. M., & Marconi, M. A. (2007). *Fundamentos de metodologia científica*. 6a ed. 5ª reimp. São Paulo: Atlas.

Marcial, E. C. (2015). Megatendências Mundiais 2030. In Ipea. Retrieved from http://www.ipea.gov.br/portal/images/stories/PDFs/livros/livros/151013_megatendencias_mundiais_2030.pdf

McNew, R. E., Gordon, J. S., Weiner, E. E., & Trangenstein, P. (2016). Distance Education Programs: The Technical Support to Be Successful. *Studies in Health Technology and Informatics*, 225, 987—988. Retrieved from http://europepmc.org/abstract/MED/27332445

Mulvaney, P. (2015). Nanoscience vs nanotechnology-defining the field. *ACS Nano*, 9(3), 2215–2217. https://doi.org/10.1021/acsnano.5b01418

Novo, M. S. (2013). Nanociências, Nanotecnologia: uma visão desde seu nascimento até apresentação das temáticas à sociedade Tese. Universidade Federal do Rio Grande.

Organization for Economic Co-operation and Development (OECD) (2017). Key nanotechnology indicators. http://www.oecd.org/sti/nanotechnology-indicators.htm

Otani, M., Alves, S., Girotto, M., Marin, M., Tonhom, S., Nascimento, E., & Silva, L. (2016). A Educacão a Distância na Formação de Profissionais da Saúde: Revisão Integrativa da Literatura. *Ciaiq2016*, 2(0), 232–241. Retrieved from http://proceedings.ciaiq.org/index.php/ciaiq2016/article/view/757

Otsuka, J., Oliveira, M. R. G. de, Lima, V. S., Mill, D., & Magri, C. (2011). Educação a Distância: Formação do Estudante Virtual

Pesquisa de Inovação (PINTEC). Instituto Brasileiro de Geografia e Estatística (IBGE) (2016). Coordenação de Indústria. 105. ISBN 978-85-240-4403-8

Pimentel, L. F., Jácome Júnior, A. T., Mosqueira, V. C. F., & Santos-Magalhães, N. S. (2007). Nanotecnologia farmacêutica aplicada ao tratamento da malária. *Revista Brasileira de Ciências Farmacêuticas,* 43(4), 503–514. https://doi.org/10.1590/s1516-93322007000400003

Pinto, A. A. M., Marin, M. J. S., Tonhom, S. F. da R., & Ferreira, & M. de L. da S. M. (2016). Métodos de ensino na graduação em enfermagem: uma revisão integrativa da literatura. Atas CIAIQ: Investigação Qualitativa Em Educação, 1, 971–980

Rita, A., Figueiras, R., Coimbra, A. B., José, F., & Veiga, B. (2014). Nanotecnologia na saúde: aplicações e perspectivas. *Boletim Informativo Geum,* 5(2), 14.

Rush, P. (2015). Isolation and Connection: The Experience of Distance Education. *Distances et Médiations Des Savoirs,* 30(23). https://doi.org/10.4000/dms.2509

Santos, A. P. dos, & Rosa, S. V. L. (2016). Uma didática para o ensino de Nanotecnologia. *Quaestio*, 18, 293–308

Serena, P., Martin Gago, J., Casero, E., & Briones, C. (2008). Unidad Didáctica Nanociencia y Nanotecnología. Entre la ciencia ficción del presente y la tecnología del futuro.

Shrivastava, S., & Dash, D. (2009). Applying Nanotechnology to Human Health: Revolution in Biomedical Sciences. *Journal of Nanotechnology*, 2009, 1–14. https://doi.org/10.1155/2009/184702

Simonson, M., Smaldino, S., Albright, M., & Zvacek, S. (2000). Teaching and Learning at a Distance: Foundations of Distance Education. *British Journal of Educational Studies* (Vol. 38). https://doi.org/10.2307/3121033

Sosa, O. G., & Manzuoli, C. H. (2019). Models for the pedagogical integration of information and communication technologies: A literature review. *Ensaio*, 27(102), 129–156. https://doi.org/10.1590/S0104-40362018002701720

Souza, C. da S., Iglesias, A. G., & Pazin-Filho, A. (2014). Estratratégias inovadoras para métodos de ensino tradicionais: Aspectos gerais. *Medicina* (Brazil), 47(3), 284–292. https://doi.org/10.11606/issn.2176-7262.v47i3p284-292

Specia, R. Z., Ramos, G. C. D., & López, O. E. C. (2016). Catálogo nacional de instituciones de investigación con actividades en nanociencias y nanotecnología - Parte 2. *Revista Interdisciplinaria En Nanociencias y Nanotecnología,* 9(17), 1–179.