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Efficient Distance Education: Model of evaluation of the use of ICT

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Abstract: This paper analyzes the current state of Brazilian distance education in relation to the use of technological park, in order to propose measures that make feasible the use of information and communication technology as a catalyst to reduce costs, enhance flexibility, and increase the quality of teaching and learning. To this end, the technological obstacles will be lifted, by means of theoretical reference, to present a minimum structure model for the operation of information and communication technology, within the necessary frameworks and adapted to the exercise of the e-learning activity efficiently and thus contribute to sustainable developmentobjectives.

Keywords: E-learning, Information and Communication Technology, sustainable development, teaching quality.

I. INTRODUCTION

In September 2015, the United Nations (UN) established the new Sustainable Development Goals and adopted 2030 Agenda [1], a new agenda of sustainable development with universal and transformative goals that encompass in a balanced and integrated way economic, social and environmental dimensions. There are 17 objectives among which this study highlights goals 4 and 11, Quality Education and Sustainable Cities and Communities. For the UN, Quality Education aims at ensuring inclusive and equitable quality education and promoting lifelong learning opportunities for all. Goal 11, however, aims to make cities and human settlements inclusive, secure, resilient and sustainable. In this context, this paper intends to contribute to these goals by proposing a more efficient technological architecture for distance learning, since this new teaching format combines technology and its tools that attend to hundreds of students simultaneously, enabling social inclusion in education.

The new interactive media can contribute to democratize access to information and knowledge, and enable the training of a large contingent of the Brazilian population through distance education [2]. In order to carry out this research, the main bibliographical references about new Information and Communication Technologies (ICT) will be raised, including how they can help to improve the current scenario of distance learning. Improving the quality of teaching contributes towards sustainable communities, since education, synonymous with teaching, is the application of proper methods to ensure the physical, intellectual and moral development of a human being. Thus, the theme of Cities and Sustainable Communities is related to other objectives established by the UN in the areas of health, education, sanitation, preservation of resources and inclusion. According to the UN [1], more than half of the world's population already lives in urban centers and it is estimated that by 2030, this percentage should rise to 70%, ie, what is not good today will get much worse if measures are not taken and innovations do not arise in all areas. ICT solutions geared to the benefit of cities are being created at all times, in companies, in the academic environments or free enterprise. But how to make appropriate and efficient use of technology? Thinking about technologies and tools for educational purposes, this study hopes to answer this main question.

In order to meet UN expectations for creating conditions for sustainable, inclusive, and economically sustainable growth, this work aims to seek solutions for improvement in higher education through the use of Information Technology and Communication. Therefore, considering the theoretical revision carried out in this work on the use of information technology in the context of distance higher education, focused on the best practices of software development and following the guidelines of sustainable development, a model of evaluation of the use of the ICT resources in the distance education model called the Efficient E-Learning Model.

The rest of this paper is organized as follows. Section II describes the bases of the theoretical foundations to understand the relevance of the efficiency of the resources of information technology and communication for distance education. Section III describes the research method used. Section IV presents the results of the study and the proposed e-learning evaluation model. The acknowledgement and conclusions close the article.

II. THEORETICAL BACKGROUND

This section presents the theoretical reference on the main themes of research: Brazilian distance education, ICT, sustainability and evaluation of e-learning platforms, thus grounding the object of study.

A. E-learning in Brazil

As reported by the latest Census of Higher Education [3] in 2016, 34,366 undergraduate courses were offered in 2,407 Higher Education Institutions in Brazil for a total of 8,052,254 students enrolled. According to the statistics presented, between 2006 and 2016 there was an increase of 62.8%, with an annual average of 5% growth. After a drop observed in 2015, the number of new entrants grew by 2.2% in 2016. This was because the distance learning increased by more than 20% between the two years, while attendance-based courses saw a 3.7% decrease in the number of students. Therefore, distance education follows a higher rate of growth than face-to-face.

Based on the analyses of previous studies, it is noticed that this growth of the distance education in Brazil has been accelerating since the beginning of this century.

In addition to the political and economic factors, what contributed significantly to the expansion of distance learning in Brazil was the technology, facilitated by the popularization of the Internet, social networks, lower-cost wireless broadband and other technological possibilities [4].

As a counterpoint, despite the successes of distance education in all sectors of learning in Brazil, particularly regarding the democratization of access to advanced knowledge, this approach faces several obstacles, often emanating from teachers who show resistance to this method and question its quality [5]. Also, it is increasingly recognized that distance education supports a strategy of commodification and privatization of education and therefore this mode needs to be researched more widely not only to be used as State policy but also to respond to new institutional and pedagogical issues [6].

B. ICT for Educational Purposes

The new ICTs in the educational context lead to the creation and evolution of distance learning proposals based on the interaction among users, with some benefits including greater agility in the implementation of e-learning, greater agility in the exchange of ideas, greater precision and agility in the consultation of teachers and tutors, and increased effectiveness in updating information [7]. It is noted that the advances of the ICTs add value to the new ways of distance teaching and learning.

Lopes [8] addresses the global market for Web Education Systems (WES). WES is in constant change worldwide, driven mainly by new trends in emerging technologies and tools that support WES, as well as the increasing role of social learning as a priority for the development process of such systems [8].

ICT is moving towards the advancement of Virtual Reality and Augmented Reality technologies which promise significant contributions in the area of educational. This seems to be the new challenge of educators, taking students in the classroom for virtual travel and teaching from interactive images that makes learning experiences more effective and attractive.

Gambling is another trend for teaching, which is to bring the dynamics of games into the classroom. Through educational games, students are encouraged to overcome challenges, which can lead to better assimilation of content and stimulate focus on tasks. The competition aspect of games increases engagement when encouraged in a healthy way.

The movement created by Web 2.0, part of the broad interaction in digital media, calls for a new model capable of better organizing and optimizing the contents and experiences of internet users. With new Web 3.0 already coming out, systems will be more prepared to better understand what users want and to more efficiently assist them. Thus, Web 3.0 will also have an impact in education, as it moves increasingly close to using artificial intelligence to know its audience, and with that, create more possibilities of action strategies.

Scholars such as Tew, Tang and Lee [9] deal with the evolution of the Internet of Technology (IoT) and the structure of Internet on Things in the educational platforms, and affirm that this new technology can make a significant contribution in virtual learning environments. The authors [9] conclude that equipping the IoT infrastructure in the educational platforms is essential to collect process data, and to perform actions that facilitate teaching and monitoring of the learning environments. Therefore, the implementation of the IoT solution can improve the performance of students, teachers, and the education system as a whole.

In this scenario of constant technological evolution, ICT management needs to have methods and resources that support it in the orchestration of the ICT media in order to achieve educational strategic objectives efficiently.

C. Distance education and sustainable development

Distance education has been promoting positive changes in Brazil's social scene, thus being a catalyst for sustainable development. If distance education brings educational challenges, it also carries opportunities for an effective means in the teaching-learning process and consequently can play a valued role in the sustainable development of society.

The mode of distance education contributes to the sustainable development of a nation insofar as its use promotes the dissemination of learning. In the current Brazilian context, distance learning has become an important topic because, especially in the higher level and professional studies, it has a determinant in social and personal development, and like any other means of social evolution, information that is treated through this conduit must have integrity and guaranteed availability. It is important to emphasize that distance learning came from the need to expand the educational system in remote parts of Brazil by helping social integration through the democratization of higher education.

The concept Sustainable Development was conceived in the Brundtland Report of 1987. This document was the result of studies carried out by a commission created by the UN [10]. In it lies the definition of sustainable development, conceived as development that meets the needs of the present without compromising the ability of future generations to meet theirown needs. Since then, the UN has followed its global conferences on sustainable development.The last conference took place in 2015, where new Sustainable Development Goals were established and Agenda 2030 was adopted, a new sustainable development agenda with universal goals that encompass the economic, social and environmental dimensions in a balanced and integrated manner.

All these movements have given significant impetus to the implementation of measures that promote sustainable development, drawing not only the attention of environmentalists, but also economists, sociologists, politicians and executives from all over the world.

D. Related work

Through the methodological process of systematic review, works related to the central theme of this study were collected. This survey was the basis for gathering the essential ideas that every evaluation model should contain, as well as the gaps left untreated. Therefore, the proposal of the evaluation model of efficiency in the use of ICT to support e-learning results from the consolidation of the studies found in the literature review and the points not addressed by the referenced authors, thus composing an unprecedented evaluation model in its structure.

All the presented works, which were listed in Table 1, demonstrate concern in the evaluation of virtual e-learning environments. One can discern common issues highlighted by these authors, such as system quality and interactive features, however, there was no emphasis upon sustainability issues, which is the focus of this proposal.

III. RESEARCH METHOD

Systematic review of the relevant literature concerning the concepts surrounding the research question was carried out. This research method aims to summarize all the existing information about a phenomenon in an impartial and complete way.

Systematic review is one of the main means to build a body of knowledge about when, how, and what processes, technologies, and tools are suitable for use in Software Engineering [11]. This method aims to identify, analyze, and interpret the available evidence related to a specific research topic or phenomenon of interest. Therefore, it is necessary to carry out a systematic review of the literature to understand the scenario of distance learning and how ICT can support it in the best way. In addition to articles published in periodicals, others sources including dissertations, theses, books and case studies were considered to support the construction of an assessment methodology.

TABLE 1 RELATED WORK

Authors	**Dimensions**	**Characteristics for evaluation of each method**
Carvalho Neto [12]	Quality of Information	Reliability, Accuracy, Authorship, Relevance, Completeness, Up-to-Date, Ease of Understanding, Interpretability.
	System Quality	Intuitiveness, Navigation, Visual Attractiveness, Performace, Security, Ease of Access, Interactivity, Functionality.
	Benefits	Stimulus Interest, Effort and Concentration, Learning Perfomace, Facilitates Learning.
	Satisfaction	Satisfaction in use, Attractive E-learning, Enjoy Use.
	Use	Frequent Use, Intention to Use, Increase in Use.
Krouk [13]	Knowledge	Providing knowledge to students.
	General Skills	Teach students to apply this knowledge, that is, to transform acquired knowledge into skills.
	Skills	Provide students with professional skills.
Wang [14]	Participation in learning activities	Frequency and hours of participation of learning activities.
	Interaction	The frequency and quality of interaction with others.
	Resource Usage	Frequency of use and quality of use of all learning resources.
	Domain of knowledge	The depth and reach of the domain of knowledge.
	Contribution to the learning community	Behavior and performance in the learning community.
Kist & Brodie [15]	Quality of Service (QoS)	Analysis of the relevance of QoS on the factors that affect QoE.
	Quality of Experience (QoE)	The factors that affect QoE: satisfaction, frustration, reach, consistency, quality, learning flow and overtime.
Wang, Zhang, Cai & Li [16]	Fields of application of IT	It deals with support services for academic and non-academic students.
	Fields of application of IT	It included tangibles, reliability, responsiveness, assurance and empathy.

One of the search criteria was the selection by works with ten years of publication, and the selection of the studies returned had four stages.The first one based on the selection criteria of the search strategy in each source of information researched:

- Integrated System of Libraries of the University of São Paulo - SIBi of USP;
- Brazilian Portal of Periodicals ofCoordination for the Improvement of Higher Education Personnel andMinistry of Education - CAPES / MEC;
- IEEE Xplore Digital Library;
- and the Science Directplatform.

The second step was the selection of the studies based on the reading of the title and the abstract. The base that had a greater percentage of use of the studies was the bibliographic base IEEE Xplore. The last step of the selection of the studies was through the complete reading of the same ones verifying if there was relationship with some of the questions of research .

IV. RESULTS AND DISCUSSIONS

Figure 1 presents the details of the proposed structure to efficiently evaluate an e-learning platform. In view of this theoretical framework, this work has as its premises the evaluation of three fundamental aspects to efficiently meet the e-learning model: Software Quality, Sustainability and Digital Interactivity. Each of these dimensions will be described below with the specification of their respective requirements.

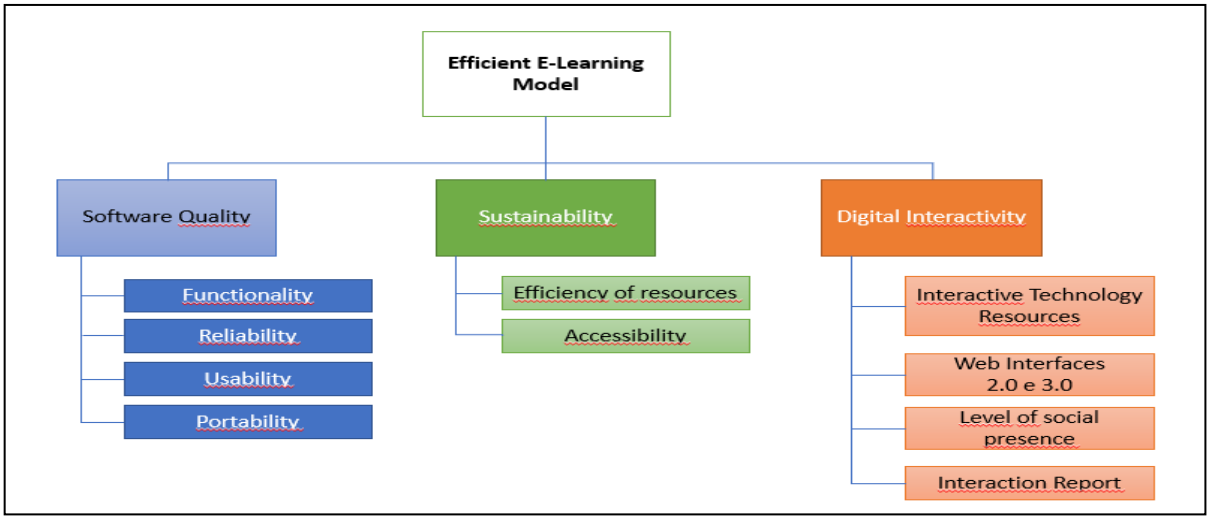
A. Software Quality

The Software Quality dimension aims to identify the essential attributes related to Software Engineering within the e-learning platform that need to be evaluated in order to provide mechanisms that enable the continuous improvement of the learning environment.

This work identifies the quality dimension of software to evaluate the requirements necessary for the optimal functioning of an e-learning platform. The characteristics ofthis dimension are in the series of standards ISO/IEC 25000, also known as SQuaRE (System and Software Quality Requirements and Evaluation), described below.

- Functionality - Refers to all necessary functions that a virtual learning software must possess to function properly to the user. The way this function is executed can be evaluated through other subcharacteristics such as security, accuracy, interoperability, and suitability.
- Usability - This requirement should evaluate the ease of use of the system. It is a very subjective feature. During the usability assessment, it is necessary to distinguish the influence of the software and the influence of the evaluator in a test [18]. Factors such as level of attention, cognitive and motor skills can alter the results of an assessment. Usability is divided into four subcharacteristics: attractiveness, comprehensibility, apprehensibility and operability.
- Reliability -The reliability characteristic of a system corresponds to the maintainance of a certain level of performance in a usage scenario. The subcharacteristics to be evaluated in the reliability requirement are: maturity, fault tolerance and recoverability.
- Portability - Indicates the possibility of a system to operate on different architectures of both software and hardware. The subcharacteristics considered for this work within the portability requirement are: adaptability, installability, co-existence.

Figure 1. Structure Efficient E-learning Model.



B. Sustainability

There are several social changes that technology has been providing to all sectors, especially in the educational area, with new proposals for teaching models. The evolution of ICTs has been increasing and boosting the offerings of the application of teaching methods. Technology is synonymous with sustainability as it is the medium of global interconnection, and distance learning enables a range of knowledge dissemination that no other model of education can offer.

Therefore, distance education is related to the concept of sustainability in the social, economic and environmental context by promoting social integration and disseminating knowledge through the sustainable technologies that bring this knowledge to the most distant populations at much lower costs.

In this context, the sustainability dimension intends to raise requirements that guarantee the efficiency of the resources used and also highlight the tools that promote accessibility in the platforms. The specification of these requirements is listed hereafter.

- Efficiency - This requirement consists in establishing minimum, maximum and average operating limits of the system in use. In order to evaluate the efficiency of a software, the SQuaRE standard has two subcharacteristics, which will be considered in this evaluation model: temporal behavior and resource utilization.
- Accessibility - This requirement should assess the accessibility level of the system in accordance with international criteria, recommendations, and standards such as heuristic assessment techniques, automatic accessibility testing, checkpoint based inspection conforming to World Wide Web Consortium (W3C) recommendations.

C. Digital Interactivity

This dimension has the purpose of providing a higher quality of teaching in this platform through the evaluation of technological resources that allow the interactivity between the parties involved and the application of methods that can measure the issue of social presence in the platform.

E-learning promotes the use of active methodologies, the objective of which is the insertion of the student as the agent responsible for the construction of learning, or the protagonist of the educational context. The speed and need for knowledge production leaves room for other methodsbeyond the transmission of knowledge by those who teach [19].

With the help of interactive technologies, distance activities are increasing the feeling of closeness between and amongst students and teachers. A web conference can bring together student and teacher. Through the chats, the students approach each other. Virtual reality, as well, makes it possible to approach the student with the programmatic content [20].

There are several tools that are used interactively in the e-learning platforms, and their use may vary according to their function in the pedagogical context and the course in question. There are also Web Interfaces tools that can be used in conjunction with the tools in the virtual environment.

As such, this model proposes that the interactivity dimension guide the identification of:

- Interactive Technology Resources - This requirement is used to identify and measure the effectiveness of the use of the tools available in the virtual learning environment.
- Web Interfaces - Identify interfaces web in the teaching process in the virtual learning environments to measure the degree of user experience.
- Level of Social Presence - Resources to measure the level of social presence of studentsthrough algorithms that evaluate the effective use of interactive tools.
- Interaction Report - Report through statistics and graphs the level of student interaction.

D. Metrics for contemporye-learning model

Based on the literature review, it will be possible to identify the goals to be reached for the definition of the desired evaluation model.

The construction of a software measurement should describe how the attributes will be quantified and combined to form indicators that provide the basis for decision making.

The pace of technology evolution calls for mechanisms to help managers choose the best platform. For this reason, it is important to obtain the means to correctly and fairly evaluate this performance and to consent to decisions that seek progress not only in terms of competitiveness but also at achieving sustainable objectives.

V. CONCLUSION AND FUTURE WORK

Distance education is facing many obstacles, but there are several opportunities for improvement and evolution in this area both in the technological aspect and in the awareness that this model guarantees and need of the teachers who can guide, teach, and interact with its students.

In this scenario, the work is justified by the need for mechanisms for continuous improvement in the use of ICT in distance education. The evolution of this format in higher education institutions has undergone a significant increase in quantitative aspects and, therefore, it is assumed that studying a proposal for a more efficient model will bring greater results in the quality of teaching and learning and consequently provide better support to this imminent growth.

Therefore, this paper aims to propose an evaluation model, the focus of which is to create requirements that allow the evaluation of the efficiency of the use of resources related to software engineering and interactivity resources, and with this, to provide greater quality and accessibility to the e-learning platforms. Thus, it is expected to meet the premises of the sustainability tripod, where not only the economic question is evidenced in the model of distance learning, but also, environmental aspects with including solutions to increase the efficiency of resource use, as well as human aspects, where there is no loss of teaching quality as it contributes to the effective education of society.

The intention of our future work is to develop metrics to evaluate the requirements of each dimension of the proposed model and to apply it as a case study in higher education institutions in the state of São Paulo.

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