Utilization of NIICTs Applied to Mobile Devices

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Abstract—Remote experiments are currently being performed on mobile devices. The intention of combining mobility and remote experimentation is to minimize the space-time barrier, providing students with faster access to information to continue their technology and engineering studies. The architecture of the technologies presented in this paper has been implemented based on the integration of a learning management system (Moodle), 3D virtual worlds (3Di-OpenSim) and remote experiments. The resources are all based on open source and open hardware provided by the Laboratory of Remote Experimentation (RExLAb) of Universidade Federal de Santa Catarina (UFSC), Brazil.

Index Terms—Remote Experimentation; Mobile Devices; 3D virtual environments; Teaching-learning process

I. INTRODUCTION

The vertiginous changes that have been occurring at a global level, particularly in communications and science, are generating profound changes in all fields of knowledge. This directly affects the educational process, particularly in teaching science and technology, which require the mediation of teachers with strategies and resources for each discipline. In this context, Information and Communication Technologies (ICT) have revolutionized all areas, including education.

Every day we are more and more immersed in a society based on information and knowledge. Such knowledge is derived from this interpretation and contextualization of information which we access through the much easier and intensive use of ICTs. In the context of the knowledge society the educational use of ICTs is becoming an essential support for education. However, technology and education should not be associated with the objective of generating quantitative improvement, in other words, only with the possibility of involving more students in the process. The real opportunity provided by NIICTs in the teaching-learning process involves its potential to serve individual needs, through personalization and interactivity, creating a new relationship environment. This encourages collaborative and exploratory learning, besides offering a creative and flexible methodology, closer to the real needs of each individual. Marc Prensky [1] in 2001 published the article entitled “Digital natives, digital immigrants” which introduces the concepts of digital natives and digital immigrants The author mentions that digital natives are young people who were born fluent in the digital language of computers, video games and the Internet, i.e. the situation of children, teenagers and youths who come to our classrooms is that they are surrounded by technology: digital cameras, mobile phones, personal computers, and various devices that are at their disposal and arouse curiosity and motivation. If ICTs are naturally part of our students’ life, why do we interrupt this process when they begin their schooling? Would it not be logical to use the possibilities of these technologies to make school more interesting and create improvements in the teaching/learning processes in the classroom?

The logical way to think about this society is that incorporating ICTs is an important factor in transforming the students’ learning process. In this context, mobile devices are gaining space within the teaching-learning environments. According to Castells [2] a major agent of social change in recent years has been the "explosion" of mobile technologies. This author says that "a key element of the diffusion rate has been the wide acceptance of technology among the younger generations, as the density of mobile users reaches its highest point". According to Agência Nacional de Telecomunicações do Brasil (ANATEL) Brazil ended the year of 2011 with 242.2 million mobile devices [3]. In other words, about 1.2 devices per individual considering the 2010 Census data published by Instituto Brasileiro de Geografia e Estatística (IBGE), which recorded a population of 190,732,694 [4]. In the same census it was also possible to extract information showing that 78% of the population between 10 and 15 years old and 91% aged from 16 to 24 years old have cell phones or similar devices. Looking at the numbers above we can see a significant rate of diffusion of mobile devices among young Brazilians who are not different from the rest of the world. We can try to explain these indices by a combination of factors that initiate the launching of new technologies, and young people use their ability to appropriate them and employ them for their own purposes.

The numbers indicate that the widespread use of mobile technologies and ownership by our young students is a consolidated process. This agrees with the discourse of Naismith [5], who said "it has no meaning, that a system of education with limited resources of information and communication technologies does not try to get the most out of what children bring to class". According to Sharples [6], educators must not think of mobile devices as enemies, but should try to exploit the potential of technologies that young people bring to them and find ways to put them to good use...
for the benefit of the practice of learning.

This short paper presents the virtual environment of teaching and learning implemented by the Remote Experimentation Lab (RExLab) at Universidade Federal de Santa Catarina (UFSC) in Brazil. This environment utilizes the resources of the open source Learning Management System platform, MOODLE, and the Arduino open hardware and Microserver (developed at RExLab). The environment deployed also provides a virtual 3D environment with access to real experiments using SLOODLE (a combination of MOODLE and Second Life) and the OpenSim virtual world server. To access mobile devices there is a supplement in the form of a plugin, the MLE-Moodle.

II. EDUCATION AND MOBILE DEVICES

Mobile technology has a great potential for use in the teaching-learning process. Mobile learning (m-learning) arises in this context. It originates in the digital convergence of mobile technology and e-learning, in response to the learning needs of an ever more dynamic society where the time available for the acquisition and construction of knowledge requires constant adaptation in this continuously changing environment.

Generally we use the terminology Mobile Learning (m-learning) when referencing studies / research linking mobility, learning and mobile electronic devices. M-learning is a relatively new research field. It is thus in progress and there is no unanimity regarding what it really is [7]. For Winters [8] the definition of m-learning is complex, because it varies depending on its original function, since “each community defines it based on their own experiences, customs and history”. In the opinion of this author the concept of m-learning should be seen from four perspectives: the technological one, focusing on the mobility device, considering the e-learning device as an extension of formal education in its “face-to-face” characteristic and, finally, the learner-centered one, which focuses on its mobility. Sharples [9] focused his studies on the fourth perspective presented to seek further insight into m-learning considered as a combined experience on five main axes, namely, mobility in physical space, mobile technology, mobility in a conceptual space from an evolving personal interest, social mobility within the different social dimensions in which we move and, finally, dispersed in time learning, as a cumulative process that collects a wide range of formal and informal experiences.

Following this line of reasoning, we can say that it is the student who moves with mobile technology and what it brings with it. This, however, should not be considered as an end in m-learning, but as a means of facilitating learning opportunities, especially when there is physical movement. Therefore, the movement in general changes the context of learning, as the process of teaching and learning is constructed in space and time through personal interactions. Extending the traditional space of classes, providing learning at any time and place, the use of technologies can accompany us in our daily lives, providing a ubiquitous learning model that enables the convergence of real and virtual contexts, allowing the customization of learning, knowledge of student profiles, access to content and educational activities without limitations of time or place.

As we saw earlier m-learning allows extending learning beyond the physical limitations of a traditional classroom. Authors like Kukulska-Hume [10] mention as advantages that m-learning:

- Enables learning at any time and place.
- Can improve the teaching interaction in synchronous and asynchronous ways.
- Enhances student-centered learning.
- Enriches multimedia learning.
- Allows customization of learning.
- Encourages communication between students and educational institutions.
- Fosters collaborative learning.

Given the arguments set out in the preceding paragraphs, it is sufficient to say that m-learning can act as an integrating element of reality, enjoying the skills of young people themselves in the digital age. As smartphones, PocketPCs and greater bandwidth and connectivity become available, the use of mobile devices for learning will be a natural progression in educational activities [11]. This makes it important to research their use and impact on the teaching-learning processes. The educational content developed in the context of m-learning can become a tool for personal use. It may become easier for the students to capture the reality of being able to immediately analyze it or share it, without restrictions of time or place and, thus, enhance their learning. The inclusion of mobile devices in the teaching-learning process will also help boost methodological changes, order models more attractive to so-called "digital natives", because they allow to continue the educational process, making use of small devices, which to some degree offer the same functionality as a computer-type "desktop" or "laptop". Mobile devices combine geographic mobility with virtuality. This allows learning in context, when it is necessary to ask questions and explore, and accurate information is needed. From this, m-learning can be seen as a new, never-ending form of personal learning, a new technological and pedagogical model, that points to a new dimension in the processes of education that can meet the urgent necessities of learning located in mobile scenarios and enable highly interactive processes. M-learning should be understood as a component that adds value in the teaching-learning process. Hence it provides interconnectivity, which reduces the dependence on place or space and offers the freedom to capture thoughts and ideas spontaneously, expanding the classroom boundaries, allowing access making resources available when and where the user needs them, and making it easier to implement innovative ways to teach classes and learn.

The emergence of mobile technology has brought many services to mobile device users, because, together with the “wireless" networks, these devices have the capability of providing powerful applications directly to the user. Their portable nature makes them very suitable for use in motion.
and extends the boundaries within which a person has access to digital information. The main feature is the ubiquity of mobile devices in teaching-learning applications, i.e. learning anywhere and anytime, that allows a greater educational environment beyond the classroom.

III. LABORATORY OF REMOTE ACCESS TO EDUCATION

One of the key aspects in teaching natural sciences and technology is to conduct experimental work in appropriately equipped laboratories, but not all students have access to such equipment. Classes where students must “verify” theories, to enable a convergence between theory and practice, are included in the semester of experimental activities at various levels of education.

The low availability of resources and laboratories for experimental activities in sciences has motivated the replacement of these statements that were made by the teacher to the entire class. Until a few years ago, practice was limited to classical laboratories, where the costs of maintenance and purchase of new instruments could become so high, that they were prohibitive for many institutions. Furthermore, when a laboratory classroom was used, the space and hours of practice for students who had access to the lab were very limited.

In the literature we find three different types of labs commonly used in teaching science and technology: the classroom laboratory (hands-on), the remote experimentation laboratory and the virtual lab. The laboratory classroom is conventionally used in classroom courses in which the students manipulate materials directly from experiments in the same space and time as their classmates in the presence of the teacher. Remote experimentation laboratories are used by students who are far away from it, but even the distance allows the student to perform remote control of the instruments and devices, that are rather different from those where they are, but an interface allows mediation between the students, the devices and the equipment.

However, the virtual laboratory is based on simulations in which the student does not interact with instruments and devices, but with computational representations of reality. For Corter [12] the remote experimentation laboratories and simulations can be at least as efficient as the traditional face-to-face teaching of specific concepts.

The use of remote experimentation laboratories began in the field of engineering, where laboratories for control and automation experiments received a strong impulse in the nineties, and today are found at centers like MIT (USA), University of Sienna (Italy), and others. Due to the need for remote access to equipment, experiments began to be adapted for virtual access, including the use of robots in handling equipment. Their use was later expanded to implement new resources to collaborate effectively in solving problems of access to classical laboratories, with the aim of:

- Increasing the practical activities in a course (students can access experiments at any day and time).
- Reducing the costs of managing and maintaining the laboratories (more people use the lab and less people do the maintenance).
- Allowing usage from any geographical point so as to reduce or minimize the costs of displacement, as well as at any time, thereby enabling problem-solving in different time zones and geographical areas.
- Integrating teaching practices, simulations, and access to equipment and devices, in the same environment.

Currently at many Higher Education Institutions (HEIs) lectures in the fields of science, technology and engineering are often complemented by remote experimentation laboratories, where students can observe dynamic phenomena that are often difficult to explain using written material. Furthermore, in the real world interactive experimentation plants increase student motivation and also develop a realistic approach to problem solving. Differently from virtual laboratories, where all processes are simulated, the remote experimentation laboratory allows interaction with real processes allowing the user to analyze the practical problems of the real world. This gives these labs some advantage over virtual labs, because according to Casini [13] the "remote labs allow students to interact with real processes". As to remote laboratories, it is concluded that they are those in which the elements are real, and virtual access is their actual experiences. According to Nedić [14], we find the following advantages in remote laboratories:

- There is direct interaction with real equipment;
- The information is real;
- There are no restrictions either of time or of space;
- There is an average cost of installation, operation and maintenance;
- There is a feedback of results from online experiences.

IV. ARCHITECTURE IMPLEMENTED IN REXLAB

The virtual learning environment implemented incorporates technological resources such as MOODLE, Open Simulator and remote experimentation, all for educational use in scientific and technological areas. Figure 1 shows the architecture of the virtual learning environment proposed and implemented by RExLab.
The OpenSimulator [15] is a “virtual worlds” Server derivative called VirtualWords with a BSD License, which can be used to create and develop 3D Virtual Environments. The OpenSimulator can be used to create an environment similar to Second Life (tm) capable of running in standalone mode or connected to other OpenSimulator instances through an embedded technology “grid”. A virtual environment like the Open Simulator can provide a structure to strengthen educational and communication processes that create a solid dialogue and cooperation group for pedagogical use, and contribute to the group learning process and to intellectual collaboration. According to Senge [16], the learning group’s main objective is to stimulate the capacity for dialogue, “for the Greeks dialogue denoted the free flow of meaning in a group, allowing new ideas and perceptions that individuals have not been able to see alone”.

The name Moodle is an acronym for Modular Object Oriented Developmental Learning Environment and it is a course management system (Course Management System - CMS), through the Internet. One of its main advantages is to be open source allowing anyone with programming skills to modify and adapt the environment according to their own needs.

This learning environment is composed of various tools to add content and activities that allow interactivity and interaction among participants of an online course, because it has some features that make it stand out compared to alternatives. One is that it was based on philosophies and teaching that was not designed from the technological point of view, but from consultation with the educational community. Since the beginning of its development it has been on a social constructivist learning paradigm. In other words, as the collaborative construction of knowledge for others is the basis of learning, where all the members of a community benefit by being creative and, in turn, are recipients of knowledge, this significantly increases the benefits of a pure constructive approach.

These possibilities offered by Moodle make it easier to produce and distribute teaching materials; resources integrated into a MySQL database also enable learning management, student assessment, access control and pedagogical support.

The plugin Mobile Learning Engine of Moodle (MLE-Moodle²), a module that is also open source, free and customizable allowing access to resources in Moodle, is installed in the same server without the need to install any additional feature in the mobile device [17].

This plugin provides the adaptation layer that interacts with the proposal of [18] regarding these situations:

- Information and Documentation: download and upload files, supporting the use of AVA and presentation of adapted teaching material, content and institutional information.
- Communication: adaptation of information synchronously and asynchronously with respect to the need of the device.
- Pedagogical and administrative management: different profiles for access and visualization of performance evaluations or queries, depending on the type of user.
- Production: development and resolution of problems or activities within the environment.

The educational material that can be downloaded from RExLab on mobile devices is in Portable Document Format (.pdf) and the presentations in PowerPoint format (.ppt). These formats can be viewed through most mobile devices and fit the different screen formats. These contents are simple to avoid making reading tiresome, with many examples and highlighting the most important points.

Another interesting feature that can facilitate the sharing and availability of online content is the QR-code, that is a 2D barcode that, when scanned, is converted to a link.

Pointing the camera for a picture of the device with the code, the user has access to the portal RExLab adapted for mobile devices. From this, with a login and password, the MLE-Moodle is accessed, with the main feature of the virtual learning environment, material teaching activities synchronized with the database and access to remote experiments, which are discussed in the following topic.

This architecture implemented by RExLab provides a powerful teaching tool, facilitating access to important laboratories that could hardly be part of the reality of public schools and, thus, can be shared among students and teachers, bringing them closer to the view of the practical effects of contextualizing teaching.

V. REMOTE INTERACTIVE EXPERIMENTS

Remote experiments are real experiences with physical elements that interact by virtual commands, so that there are no restrictions and no time or space: they are direct interactions with real equipments. We have the real-time feedback of the experiment results online, and a key point is the low cost of installation, use and maintenance [19].

Therefore, the user can remotely activate the experiences available through connection with wireless Internet access and use the browser of the device, Fig.2. The site is developed in PHP and JavaScript for interface use, enabling interaction with the experiments that are connected to the web or microserver Arduino boards with an Ethernet port.
Figure 2. Remote experiment on an Apple iPhone 3G

Interacting with the experiment on the Internet, data are sent to these devices that trigger relays. These in turn control actuators and make the experiment work physically. The user can observe the effects in real time through streaming video from a directed IP camera.

Therefore, the environment enables the remote control of different devices such as motors, circuits, sensors and safety systems, while watching the dynamic effects, which are often too complex to explain, but understandable regarding realistic approaches to solving problems.

Another important technological value is the touchscreen interface, adapted to provide better control and greater reality, even when operated for lab use. The simplest devices already have this feature, and are easily adapted to interfaces which use the mouse to interact. Fig. 3 shows the display on an Apple iPhone 3G iOS 4.2 interface MLE-Moodle (Moodle Mobile Learning Engine).

The tool also provides playback extending the use of equipment and demonstration showing the achievements of the research group of laboratories. Thus, there is a diversification of results and extension of experiences, integrating experiments that allow the demonstration of most concepts studied in science lessons in the classroom and the practical advantages of understanding them, therefore benefiting student learning.

Figura 3. Interface MLE Moodle accessing the RExLab

VI. CONCLUSION

The NICTs play a key role in the overall process of change experienced by society. Therefore, it is necessary to consider the technological options to be applied by the teacher in the teaching process, specifically in the fields of science and technology.

The use of mobile devices is growing rapidly and their use in education has major implications in the teaching-learning process. This includes mobile learning, characterized by its ability to deliver learning content without boundaries of time and space through mobile devices such as cell phones, PDAs, small computers and/or all handheld devices that have wireless connectivity in order to maximize the time available for learning. Thus mobile learning is a new possibility to access various learning resources from anywhere, at any time, giving the students the opportunity to learn in real time, in the most appropriate setting and context in relation to their objective and learning style.

The students can take advantage of the opportunities that mobile devices allow to deliver in education. Thus, the presence of these resources is a daily reality and a constant for students who grow surrounded by NICTs. These features significantly expand learning contexts to complete ubiquity. Any scenario, real or virtual, thanks to NICTs and especially to mobile devices, is a potential space for learning.

Access to remote laboratory experimentation with interactivity provides an environment for technological and scientific users. This environment is characterized by this reality, space requirements and devices, similar to hands-on laboratories, but distinguished by geographical location.

The students’ interaction with the real experiments differentiates remote experimentation from virtual simulations, because these results are not programmed perfectly to reflect the real physical effects. Interacting and visualizing the result of practical experiments, RExLab enables students to develop the concepts better and accessibility of these resources depends only on devices connected to the Internet. The usability of mobile devices and computer labs tends to provide an extra resource to enrich teaching and learning at a low cost to a broader group of users, and is a way to share resources.

The practicality and interactivity, with a proper layout, attracts attention to the study and, in this case, interacting with real experiments tends to increase interest through the technology involved. Heretofore, the control of these phenomena could only be theoretically observed.

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