Collaborative virtual community to share class plans for STEAM education

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***Abstract*— This research presents an international community of practice for teachers using the VISIR remote lab. Throughout the research, it was necessary to study about communities of practice and their potential use in remote laboratories; identify practices with collaborative potential in the institutions and with the participating teachers; develop the necessary technological environment to support the proposed community of practice; validate the proposal with four institutions (four countries - Brazil, Portugal, Spain and Argentina) to evaluate the proposed model. The motivation for developing this research came from the history of the Remote Experimentation Laboratory (REXLAB) with the project VISIR+: Educational Modules for Electric and Electronic Circuits Theory and Practice following an Enquiry based Teaching and Learning Methodology supported by VISIR+". The VISIR + project is an international cooperation project with the participation of 21 Ibero-American partner institutions between October 2015 and April 2018. The platform, called Labs4STEAM, was developed using Dokuwiki, an open source wiki software that contains a large number of plugins. From the data collection it was possible to receive a mostly positive feedback, but several improvement opportunities were pointed out, which will be performed soon. Thus, from the developed platform one can plan future work, taking into account the results obtained and experience and partnerships with the VISIR + project.**

Keywords—Community of practices, Remote laboratories, Virtual online environment, STEAM.

I. INTRODUCTION

The popularization of Information and Communication Technologies allows the creation and discovery of new tools and possibilities previously difficult to explore, as digital resources break down barriers such as distance, time and space [1]. One of the biggest opportunities was the opening of new online applications in network environments [2]. The Internet is today the most widely accessed platform that millions of people today, anywhere, anytime access daily [3].

Tools that provide teacher-focused collaborative environments enable teachers to work together to share classroom experiences. Therefore, participation in a community expands the innovative potential of a teacher who already has access to technology and facilitates the process of adapting a lay teacher in relation to these resources, as there is a whole new possibility for discussion, exchange of tips and learning [4].

One of the clearest definitions of the concept of Community of Practice (CoP), which is widely cited, was elaborated in a research by Étienne Wenger [5], creator of the concept. This definition states that communities of practice are groups of people who share an opinion, a set of problems, or an admiration for a topic in order to deepen their knowledge and experience in this area through interactions with others [6]. Thus, the concept of communities of practice covers a peer work perspective, as opposed to an individualistic perspective.

The construction of the concept of communities of practice is based on learning and its dimensions and can be seen as a social learning system [6]. For Wenger [7], social scientists have used versions of the concept of communities of practice for a variety of analytical purposes, even though their origin and use of the concept are found in the area of learning theory.

Therefore, the concept of community of practice fits in well with the development of a collaborative online environment suitable for teachers, since the framework allows teachers to interact both teaching and learning, allowing them to share their own experiences, also understand your colleague's experience and know how to replicate it, advise it, and work not only in a team but in a community way.

Participation in a community expands the innovative potential of a teacher who already has access to technology and facilitates the process of adapting a lay teacher in relation to these resources, as there is every possibility of discussion, exchange of tips and learning. Registered teachers can submit their classroom practices to the environment and other teachers can access them and talk about their application.

From the research, we sought to develop a tool for teacher interaction, allowing teachers to share lesson plans with partners from different parts of the world, and sharing experiences. Initially, the platform was designed to house lesson plans that made use of the remote VISIR laboratory, a tool aimed at supporting the teaching of theory and practice in electrical and electronic circuits. However, it became more interesting to expand the platform's audience, making room for lesson plans that made use of not only other remote labs, but also simulations.

A remote laboratory is a type of experimentation in which the experimental apparatus and the user are physically separated, and the execution of the experiment depends on a means of communication (Internet) between the user and the remote laboratory, usually through a user interface [8]. Therefore, a student accessing a remote laboratory will have an experience very similar to that of accessing a traditional laboratory, since the result of his experimentation will vary depending on the current conditions of the environment where it is applied.

The remote laboratory, which aims to support the teaching of theory and practice of electrical and electronic circuits, was widespread throughout Europe, so teachers using the tool had

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a lot of experience to add to new teachers. From this assumption came the idea of spreading the use of VISIR in Latin America. The VISIR + project was an international collaboration project supported by the European Commission under contract 561735-EPP-1-2015-1-EN-EPPKA2-CBHE-JP in the Erasmus + program during 2015 to 2018. The project was started at the Blekinge Institute of Technology (Sweden) to disseminate the use of the VISIR remote laboratory to Latin America.

This research aims to present the development and testing of a virtual practice community aimed at teachers of STEAM (Science, Technology, Engineering and Mathematics) disciplines in order to promote discussion and sharing of lesson plans among teachers. On this platform, called Labs4STEAM (Labs for STEAM), teachers from around the world can submit their lesson plans, download class plans from classmates and discuss online. The elaboration of the platform allows the sharing of lesson plans that make use of both VISIR and other remote labs and even simulations. The tool allows knowledge and practice sharing, allowing a bridge between several educational institutions around the planet. Therefore, such a tool opens an opportunity for sustainability of the VISIR + project.

II. METHODOLOGICAL PROCEDURES

A. Classification of the research

The table below presents the procedures adopted. Thus, it is expected that, with the information presented here, the study will be understood more clearly and can be replicated more easily by other researchers.

TABLE I. CLASSIFICATION OF THE RESEARCH

Aspects	Classification
Nature	Applied research
Problem Approach	Qualitative research
Objectives	Exploratory research
Technical Procedures	Bibliographic research and case study

Considering the nature of this research, it fits in as applied because it is concerned with the generation of knowledge to solve real-life problems, involving local truths and interests [9].

Qualitative research somehow establishes "a dynamic relationship between the real world and the subject, that is, an inseparable link between the objective world and the subjectivity of the subject that cannot be translated into numbers" [10]. In this category, the environment itself is considered a direct source for data generation and the researcher, a key instrument [9].

Regarding the classification of the research according to its objectives, Gil [11]and Silva and Menezes [10] classify the research into three major groups: exploratory, descriptive and explanatory. According to Gil [11], the explorations aim to make the problem more familiar, making it more explicit to the researcher. Marconi and Lakatos [12] agree by explaining that this type of research promotes a first contact with the theme, seeking to clarify the related facts and phenomena. Usually this type of research is performed when there is little knowledge about the subject.

Corroborating with the authors Marconi and Lakatos [12], the bibliographic research is seen as "a general overview of the main works already carried out, of important importance, for being able to provide current and relevant related data". The bibliographic survey is intrinsic in scientific research, thus, all academic works are somehow framed as bibliographic. In this sense, this work is intrinsically linked to this procedure.

Given the profile of the activities developed, it is possible to define the research regarding the technical procedures as "case study", although the research provides interaction between the researchers involved in the investigated situations, which could also allow its classification as a "participant research".

B. Research steps

The first stage was dedicated to prepare a bibliographic foundation for the research base. Research was conducted on the main concepts related to this work, such as Communities of Practices, Remote Laboratories, Collaborative Virtual Platforms, among others.

Simultaneously, it was time to begin the elaboration of academic works related to the process of development of this work, reporting from the results of the bibliographic research, to the development of the platform, among other themes identified as relevant for publication.

After the bibliographic research was elaborated, it was possible to start the development process of Labs4STEAM.

Right after having this initial idea of the platform, it was time to make an initial contact with potential partners. To this end, a series of field research was carried out in order to hold meetings on the sustainability of the VISIR + project, where the need to create a platform for sharing practices with the remote VISIR laboratory was fitted.

After the development of the platform and initial contact with partners, it was time to apply the platform test questionnaire sent to all experts involved with its use. Soon after receiving all the answers, it was time to analyze and tabulate them.

With the conception of the results, it was time to write the conclusion of this work. After the conclusion of the conclusion, it was possible to prepare academic papers for publication based on the results of this study.

C. Procedures: Data Collection

The data collected for the research were collected from the case study. Thus, the data were analyzed in the qualitative analysis style.

Thus, to achieve the objectives proposed in this research, a questionnaire was prepared based on the work "Guidelines for the Evaluation of the Learning Objects Usability" [13]. The authors of this paper have developed guidelines based on theoretical studies and learning object analysis by a technical team and teachers involved in the production of learning objects. From a theoretical framework study and case study with teacher training, a list of guidelines for the evaluation of the usability of learning objects was elaborated [13].

The guidelines are:

- Present an initial contextualization, describing the theme/content on the object
- Present the pedagogical objective related to the use of the object

- Present the expected usage context for the object
- Highlight how the object could be pedagogically explored
- Provide supplemental material, preferably from the authoring team

The guidelines related to "Prioritize the digital" prioritize the development of learning objects that do not need, for their use, application or program that is not freely available on the web [13]. The following are the guidelines:

- Explain what software is required for object execution
- Take accessibility issues into account, enabling keyboard navigation
- Take accessibility issues into account, allowing the object to work in different browsers (or alerting the user if it does not)
- Avoid making available files (only) in PDF format, for presentation of the object and / or material complementary to its use, which are inaccessible via screen readers.

The guidelines related to "Providing assistance to users" provide user assistance via the interface and easily accessible instructions [13]. The following are the guidelines:

- Provide clear indications on how the object is used, indications available on the user interface itself and / or easily accessible from it.
- Use language appropriate to the user type and object application domain
- Present constructive error messages that allow the user to redo their choices without interrupting the use of the object.

The guidelines related to "Providing interactivity" provide error prevention (disabling what cannot be done, presenting specific data entry formats when necessary) [13]. The following are the guidelines:

- Provide error prevention (disable what you cannot do, display specific data entry formats when needed)
- Provide easy-to-remember forms of use / interaction, not excluding the need for accessible instructions at all times
- Explore the resources of the technologies employed (hypertext, flash, video, etc.)

"Providing interaction" guidelines Allow actions among users (students, teachers, tutors, etc.) from and /or on the object [13]. The following are the guidelines:

- Provide options for sharing results with teachers, peers, or the wider community (for example, using a blog to make it available and maintain)
- Provide discussion channels among your users
- Specify interaction activities among students among the activities intended for the use of the object.

The guidelines related to "Being self-contained" require that the object must focus on a particular subject and explain it without necessarily relying on other objects and / or materials [13]. The following are the guidelines:

- Select the appropriate amount of information that represents the specific content of the object.
- Present content in a way that does not address other subjects and distract student attention

To adapt to the case study questionnaire developed in this paper, each set of guidelines has been separated into sections using the free Google Forms platform (https://www.google.com/forms/).

The questionnaire was emailed to a list of 11 experts with experience in the VISIR + project. These specialists should be researchers with experience in the VISIR + project. They could be teachers or professionals in the field of educational technologies and could live in any of the countries where the project was applied.

III. Results

A. The Labs4STEAM Platform

The Labs 4 STEAM platform was developed using Dokuwiki, an open source wiki software containing a large number of plugins [14]. According to Dokuwiki's official website homepage [15], the software is admired by its users for its clean and easy-to-read syntax, as well as its easy maintenance, backup and integration. Built-in access control and authentication connectors make Dokuwiki especially useful in the corporate context and the high number of plugins built collaboratively by your community [15].

Initially, the platform would only provide access to lesson plans related to the use of the remote VISIR lab. However, in thinking about the platform's expansion and greater popularity among its future users, it was decided that the platform would also accept other remote labs, and in the future even simulations.

The platform was developed during the first half of 2018 and is available for access in September 2019 and is available at: http://labs4steam.rexlab.ufsc.br/

A difference in permissions has been established between registered users and visitors to strengthen the platform's security and to prevent possible interventions by an unselected audience to use it. Only teachers may discuss and submit new practices. The administrator checks each platform registration request.

The platform is available in English, Portuguese and Spanish. However, for purposes of limitation, not all practices are available in all languages. The platform allows the translation of its interface, but not the content posted manually by the user. Therefore, it was proposed to users that the platform is willing to receive volunteers who can translate the practices into other languages.

Following are some screenshoots of the platform. Below is the Portuguese home screen, with introductory text, links to the official REXLAB website and its products, and information on how to submit practices for publication on the site, as well as instructions for registering on the platform.

The following figure shows the Labs4STEAM home screen in Portuguese. Alternatives to other languages are still open as translation will be done voluntarily by platform users.

Fig 1. Labs4STEAM home screen

The figure below presents an example of a lesson plan registered in Labs4STEAM. The lesson plan consists of a title, the name of the teacher, the name of the subject, the course within which the subject was taught, the duration of the lesson, the target audience, the educational institution and the materials used. After this information, there is a program to explain when each class activity took place.

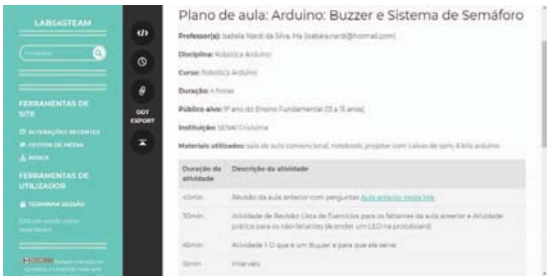

Fig.2. Labs4STEAM home screen

The platform also has a feature for its users to download each lesson plan registered in .ODT file, after clicking the "ODT EXPORT" button. This feature allows, in addition to the printing of the lesson plan, its offline use and the possibility of editing to adapt to the reality of the teacher who wants to replicate it.

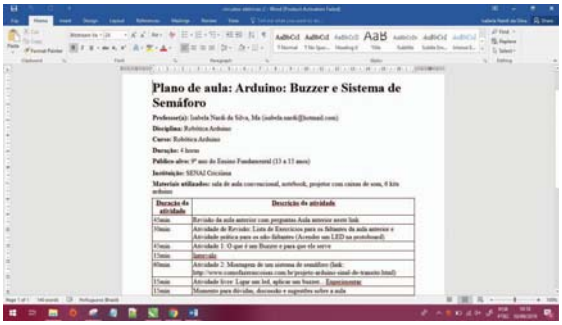

Fig 3. Labs4STEAM home screen

B. *The Labs4STEAM Platform*

This subsection will present the answers of the experts to the questionnaire. In order to make the research more succinct, 1 question from each category were selected for presentation.

It can be seen that many experts pointed out the "indifferent" alternative on some issues. This is because the platform is hosted on a server located in REXLAB, at Federal University of Santa Catarina. The building REXLAB is located has suffered from many power outages due to a series of storms that occurred during January 2018.

Thus, the platform was unavailable and the only way for experts to view it was through an explanatory video. This video had been made prior to the platform deactivation and would only complement the introduction of the questionnaire, so it was not equipped with the answers to all the questions. However, many of the answers could not be answered just by watching the video, so the experts could not agree or disagree with some of the statements presented.

Silveira and Carneiro [13] stipulate some guidelines for the evaluation of learning objects. The first of these guidelines is called the Platform Pedagogical Objective. This guideline should provide clear guidance so that the student knows what he is expected to learn by using the learning object and the teacher (different from who produced the object) knows how to use it [13]. As can be seen from the graph presented below, the ninth question was related to the user's introduction to the platform, in order to verify if it was properly presented in order to know the purpose of the platform and the content to be treated.

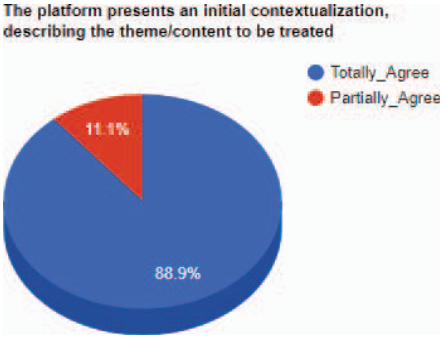

Fig. 4. Results for the ninth question: "The platform presents an initial contextualization, describing the theme/content to be treated"

Most experts (88.9%) confirmed that the platform presents an initial contextualization in order to describe the content to be treated; 11.1% partially agreed.

The second guideline, called "Prioritize the digital", should prioritize the development of learning objects that do not need, for their use, application or program that is not available for free on the web (SILVEIRA E CARNEIRO, 2012).

The seventeenth question asked the expert if the platform enabled keyboard navigation, considering accessibility issues, such as visual impairment. The chart below gives the answers to this question:

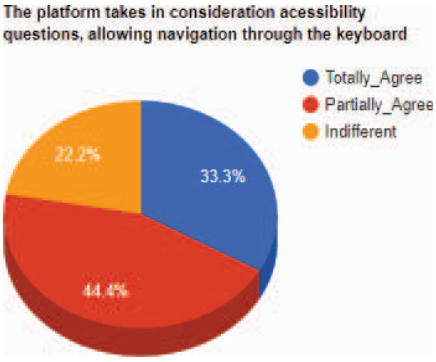

Fig. 5. Results for question seventeen: "The platform takes in consideration acessibility questions, allowing navigation through the keyboard"

Most experts agreed with the statement (77.7%), but 22.2% of respondents were indifferent.

According to Silveira and Carneiro [13], the third guideline is called “Providing assistance to users”, and should offer user assistance via easily accessible interface and instructions.

The twenty-second question was related to the indications regarding the use of the platform by users, presenting the statement “The platform presents clear information for its mode of use, indications provided in the interface and/or easily provided through the interface”. The graph below presents the results for the question:

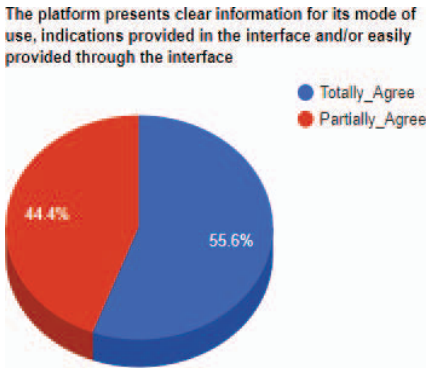

Fig. 6. Results for the twenty-second question: “The platform presents clear information for its mode of use, indications provided in the interface and/or easily provided through the interface”

As can be seen, all experts agreed with the statement, but 44.4% agreed only partially.

Silveira and Carneiro [13] define the fourth guideline "Providing interactivity", as "providing the user can interact by performing actions with the object". This guideline is closely related to the aesthetics and layout of the learning object.

The forty-fifth question had the following statement: "The platform maintains a standardization of its layout (use of colors, fonts, etc.)." The following chart presents the results for the question:

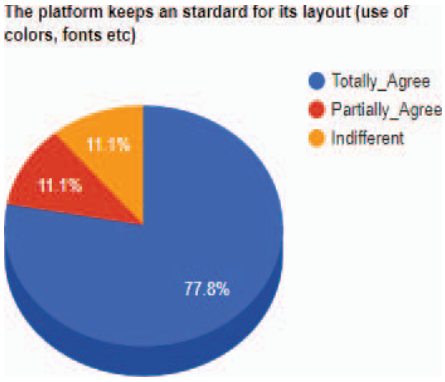

Fig. 7. Results for the forty-fifth question: “The platform keeps a standard of its layout (use of colors, fonts, etc.)”

It can be seen from the graph that most experts (77.8%) totally agreed with the statement; however, 11.1% partially agreed and 11.1% were indifferent to it.

The fifth guideline is called “Providing interaction”, and consists of allowing actions between users (students, teachers, tutors, etc.) from and / or on the object [13].

The forty-eighth question asked the experts whether the platform came from sharing results with other members. The results for this question are as follows:

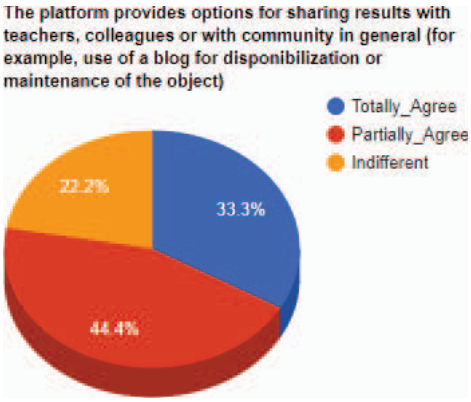

Fig. 8. Results for the Forty-eighth Question: “The platform provides options for sharing results with teachers, colleagues or with community in general (for example, use of a blog for availability or maintenance of the object)”

Most experts (77.7%) agreed with the statement (33.3% fully and 44.4% partially), and only 22.2% were indifferent.

The sixth guideline, “Provide constant feedback”, should keep the user always informed of the current state of their interaction with OA [13].

The fifty-first question presented the statement "The platform provides clear indications of what the user must do to proceed to the next steps of its use (next step messages)." The following chart presents the results for this question:

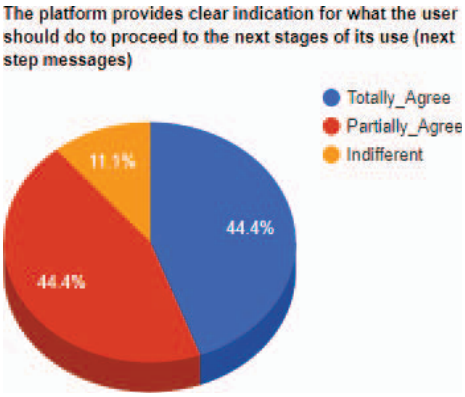

Fig. 9. Results for the fifty-first question: “The platform provides clear indication for what the user should do to proceed to the next stages of its use (next step messages)”

Most experts (88.8%) agreed with the statement (44.4% fully and 44.4% partially), but 11.1% were indifferent.

According to Silveira and Carneiro [13], the seventh guideline is called “Being self-contained”, in which the object must focus on a particular subject and explain it without necessarily depending on other objects and / or materials.

The fifty-eighth question presented the statement "The platform does not require the search for external information to understand the activities and contents presented in the object". The following graph presents the results for the fifty-eighth question:

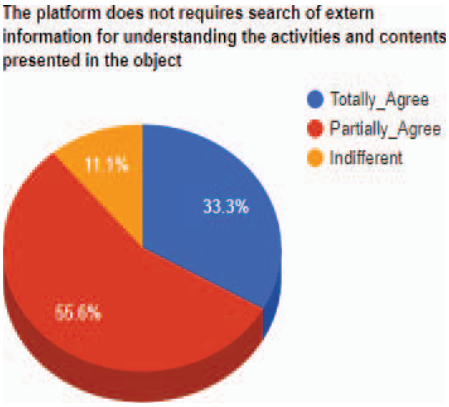

Fig. 10. Results for the fifty-eighth question: "The platform does not requires search of extern information for understanding the activities and contents presented in the object"

For the results of this question, 55.6% of the experts partially agreed with the statement, while 33.3% totally agreed and only 11.1% selected the "Indifferent" alternative.

IV. Conclusion

The present research had as proposal to present a collaborative virtual community proposal for teachers using remote laboratories.

From the data collection performed by applying a platform verification questionnaire to a group of experienced experts regarding the VISIR + project, we could receive feedback from the platform. Most of the answers were positive, but there are some details to adjust here, such as better clarity of instructions for the user to understand how to use platform tools such as discussion channels.

This comment presented on the "Improvement Opportunities" discursive question also provides a good critique for future platform enhancements: "Some usability issues I didn't find so necessary because they are easy to interact with, but for a lay user it can be a hindrance [...] ".

Through this research it was possible to realize that the developed platform was welcomed by the specialists, who, during the field visits, even suggested partnerships to elaborate future works. After all, as presented in the Results chapter, the platform has great potential and only needs a few modifications to be suitable for use by teachers in general.

Next steps will be in terms of dissemination and effective use of the platform.

Thus, from the research developed, future publications can be planned, taking into account the results obtained and experience and partnerships with the VISIR + international cooperation project. Related to the VISIR + project, the platform also functions as a sustainability tool for the project.

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