

# Block.ino: Remote Lab for Programming Teaching and Learning

Juarez Bento da Silva<sup>1</sup>, Graceline de Oliveira<sup>2</sup>, Isabela Nardi da Silva<sup>3</sup>, Paulo Manoel Mafra<sup>4</sup>, Simone Meister Sommer Bilessimo<sup>5</sup>

<sup>1,2,4</sup> Post-Graduate Program in ICT, Federal University of Santa Catarina, Brazil

Email: [juarez.b.silva@ieee.org](mailto:juarez.b.silva@ieee.org); [graceedeoliveira@gmail.com](mailto:graceedeoliveira@gmail.com); [paulo@mafra.eti.br](mailto:paulo@mafra.eti.br); [simone.bilessimo@ufsc.br](mailto:simone.bilessimo@ufsc.br)

<sup>2</sup> Robotics Instructor in Social Service of Industry – SESI, Brazil

Email: [isabela.nardi@hotmail.com](mailto:isabela.nardi@hotmail.com)

**Abstract**— This article introduced the remote lab Block.Ino to support the teaching and learning of computer programming. In a remote lab user work with equipment or devices and observe activities through a web camera. The validation was performed in order to understand the acceptance of the services and resources available. It was performed in two scenarios where Block.Ino was employed to perform practical online activities. Questionnaires were applied that sought the perception of the respondents about their experience using the remote laboratory. The questionnaires included items related to usability, learning perception, usefulness and satisfaction, by the two focus groups of the research (presential higher education and basic education). 144 students participated in the research (103 high school and 41 higher education). The average scores for the 24 items, arranged on a Likert scale of 5 (-2 to 2) points, were 1.58 for high school and 1.43 for higher education. The results showed that Block.Ino can bring benefits to practical activities in introductory computer programming disciplines, especially outside the classroom environment, by taking advantage of existing connectivity, and by using mobile devices to perform practical activities.

**Keywords**— Teaching and learning, Programming teaching, Remote laboratory, Block.ino.

## I. INTRODUCTION

The remote laboratories (LR) provide resources to perform didactic practices that in the various fields of knowledge. In a remote lab user are able to work with equipment and devices and observe activities through a webcam, mobile device or microcomputer. The act of accessing resources from a remote laboratory to perform a practical activity may be called experimentation. According to Carnegie Mellon University (2000), running experiments from a remote location is called remote experimentation. This experimentation allows the user to interact with the real world through electronic control and monitoring and control systems accessed by computer devices.

The remote lab helps students gain information from the Internet by searching for it directly in the physical world and allows them to access resources that institutions sometimes lack, and remote labs are a financially useful tool as they that can be shared with various educational institutions and enable a large number of users to access them. [1]. Remote labs can make learning more flexible about the student's time, place, and pace, and practice can be tailored to schedule and promote self-learning. [2].

Figure 01 illustrates the process of operating a remote laboratory.

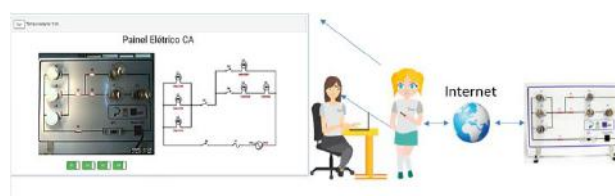


Fig. 01: Example of access to the remote experiment.

Source: Authors.

Figure 01- Example of access to the remote experiment. Source: Authors.



Fig. 02: Online labs.

Source: Zutin, Auer, Maier & Niederstätter, 2010.

According to the authors, online laboratories can be grouped according to three types, as illustrated in Figure 02 and thus described. Online labs include simulations (virtual labs) where you can reproduce any kind of experiment without restrictions and real experiments (remote labs), whose interaction is mediated by ICT, where the student can manipulate real materials and equipment in a different location than which is found [3]. In an online laboratory, research parameters can be manipulated and the effects of this manipulation are observed to obtain information about the relationship between variables in the conceptual model underlying the online laboratory [4]. According to Zutin *et al.* (2010), Figure 02, online labs can be divided into two main groups: “Virtual Labs” which are web-based software simulations and “Remote Labs”, which consist of real hardware equipment, or that is, it is a real experiment, located in a different space from the student, and the contact between them is mediated by an ICT. The intersection of the two types creates the concept of “hybrid lab”.

Although a relatively new subject in terms of educational research, remote labs are not a very recent feature. The Second Best to Being There (SBBT) at the University of Oregon State and commissioned in 1995 is recognized as the world's first remote laboratory. The SBBT aimed to enable students to remotely control a robotic arm. The technological resource was used in the Control Engineering discipline [6]. In 1997 the UFSC Remote Experimentation Laboratory (RExLab) presented the project of the same name, which allowed the user to run a program for the 8051 microcontroller developed in the Laboratory. It was a laboratory to complement the teaching of microcontrollers where the student studying the 8051 microcontroller. This is considered to be RExLab's first remote lab and was cited and used as an example in Myke Predko's Programming and Customizing the 8051 Microcontroller [7].

In recent decades, many educational institutions have been researching new ways to adapt traditional teaching methods to the modern habits of society. In this context, remote laboratories present themselves as a fully aligned resource, but still little explored in the area of education. The following are some advantages indicated by some authors for their use by educational institutions:

In terms of use, its application can reach all levels of school, ie from basic education, technical education and higher education. Thus, we could, for example, to support the courses, in the distance learning mode, the LR can bring improvements in products, processes and creation of new service, for example, provide laboratory practices via

the Internet. Data collected in the e-MEC System (<http://emec.mec.gov.br/>) [8], on 21/08/2019, showed the existence of 389, in the areas of engineering and computing, totaling 680,260. For these courses, LRs can contribute to answering questions about the impossibility of addressing certain subjects in an e-learning modality, as they provide Internet access and overcome spatiotemporal barriers for people and resources.

In higher education laboratory resources, in many institutions there is insufficient resources, given the requirements of classes conducted in a laboratory environment (number of students per class, amount of equipment, etc.). This presents the need to overcome the challenge of providing educational environments that provide more access to practical activities. LRs contribute to meet this challenge through a new approach and tools for practical activities. And present itself as an important support tool for classroom teaching, assisting teachers in their practices.

In basic education, experimental activities help inspire teens and young people to practice science, technology, engineering, and math, as well as provide tools for teachers to make their classes more attractive and aligned with the real world. It is not difficult to realize that many young people find the virtual world more exciting than the school environment they attend, because they perceive it far from the world in which they “live”. There is a need to have more attractive teaching and learning environments and not considering this, may imply the demotivation and disinterest of students. Perception, which weakens training, especially in the STEM areas. For example, basic theories and mathematical models of natural phenomena are presented in a “traditional” way (concepts presented in oral sessions), and the complementation of this formation should take place through the use of physical experiments conducted in instructional laboratories. However, the availability of laboratory equipment is poor or non-existent in many elementary schools. According to the 2018 Census of Basic Education, in Brazil, in relation to public schools of basic education: 38% have computer labs, 54% have broadband internet, 8% have science labs and average computers for student use. per school is 6.73.

## II. THE REMOTE LABORATORY BLOCK.INO

The LR Block.ino, object of study of this research, aims, according to Carlos, Lima, Simão & Silva (2016), offer an experimentation environment directed to the creation and execution of programming codes with the possibility of access and manipulation of real devices, as well as to verify their operation and performance in real time by streaming video. Its application is directed to

teaching programming logic in computer programming and robotics through the use of mobile devices, using visual programming environment, using blocks to control a remote Arduino platform. LR Block.Ino is a framework for developing and running programs on an Arduino board that can control sensors and actuators via remote access via the Internet. Its applicability, in the educational scenario, can occur in all levels: Basic, Technological and Higher Education.

Regarding Basic Education, many educators see coding as a way to stimulate computational thinking: the required ability to learn to code combines in-depth knowledge of computer science with creativity and problem solving. Additionally, the arrival of user-friendly tools including Arduino, Raspberry PI, Scratch and LegoNXT are making it easier than ever for students to get started on coding learning [10].

In higher education, the subjects of introduction to programming, there are several denominations, for example: Introduction to Computer Science, Introduction to Computer Programming, Programming Logic, Algorithms, among others, are present in the curriculum of several courses, in the various areas, not just the exact ones.

However, students, especially freshmen, find it very difficult to understand these concepts, leading to failures or locking in the discipline and even dropping out of the course. That is, it is one of the existing bottlenecks, especially in the exact area courses, making it difficult for students to continue in the course [11].

For the two scenarios addressed, the commonality is the need for more attractive teaching and learning environments. It is essential to extend this technological perspective not only to the classroom, but also to the school, and to enable thinking as a process of action (doing) and the creation of knowledge (knowing). Favorable context for the use of LR [12].

In this context, LR Block.ino is presented, for conducting computer programming experiments, seeking to appropriate existing connectivity and offering students of different educational levels, resources for learning.

Access to LR Block.ino, as shown in Figure 03, is from the Remote Labs Learning Environment or simply RELLE [<http://relle.ufsc.br>], where others are available. RExLab and Partner LR. LR Block.ino is currently available in four languages: (1) Portuguese; (2) English; (3) Spanish and (4) French.

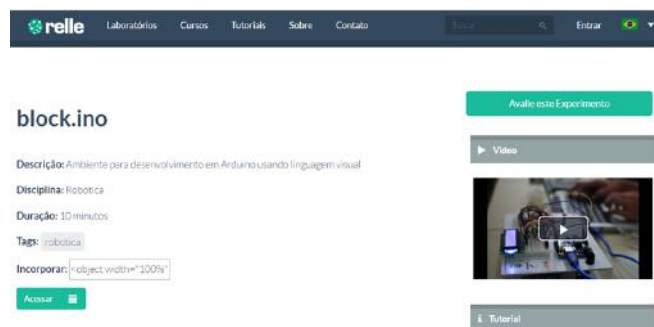


Fig. 03: LR Block.ino access page.

Source: Authors

Figure 03 - LR Block.ino access page. Source: Authors

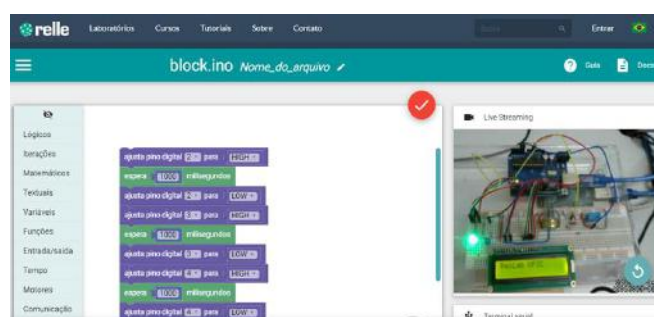


Fig. 04: LR Block.ino access page.

Source: Authors

LR Block.Ino was implemented from a client-server architecture and its development process was divided into three steps. As shown in Table 1, in more detail [9].

Table 1 - Steps of Block.ino development.

Steps	Processes
Arduino Remote Lab	Arduino Uno board, sensors, actuators connected to protoboard. An acrylic case accommodates the components. Raspberry PI connected to Arduino card via USB.
Client Application	Use of web technologies; Responsive Designer. Blockly library in charge of the creation of blocks.
Lab Server Application Development	Remote Lab is a standalone resource connected to the internet. Operation based on an application programming interface (API). Using Raspberry PI to process the application. Node.js is processed and triggers the API. WebSocket protocol is used to transport data exchanged between client and server.

Source: (Carlos et al., 2016).

Since access to the LR can only be performed by one user at a time, given that there is a queue that must be respected. To minimize the problem with the queue, LR replication process was used and thus provide access to

multiple Block.ino instances. Thus contributing to a greater number of users could simultaneously access different instances for didactic practices in the Arduino development environment [13].

### III. MATERIALS AND METHODS

The validation of the LR, with an evaluative and observational profile, contemplated two scenarios: high school and computer course in higher education. The instrument applied was a questionnaire that sought the perception of respondents about the experience and use of remote laboratories. The questionnaire was constructed from the instruments developed by Professor Euan David Lindsay of Curtin University in Australia [14], and another by professors Sergio López, Antonio Carpeño and Jesús Arriaga of the Universidad Politécnica de Madrid [15].

The adapted questionnaire included items 24 related to usability, learning perception, usefulness and satisfaction by the two focus groups of the research. The 24 items, composed of objective questions, were distributed in the domains: usability (6), learning perception (6), utility (6) and satisfaction (6).

The items of the questionnaires were arranged in a Likert-type scale of five, consisting of items in the form of statements, on which the degree of satisfaction should be displayed, see Table 2. In this context, the number of students (frequency) was considered. which ticked all the alternatives to perform the percentage calculation [16].

Table 2: Scale of numerical values with defined scores.

Strongly Disagree (SD)	Disagree (D)	Neither agree nor disagree (NO)	Agree (A)	Strongly agree (SA)
-2	-1	0	1	2

Source: Authors

For purposes of data analysis, it was decided to perform and establish the average score for the answers of each item, obtained in the questionnaire based on the Likert scale used in this research. To estimate the reliability of the questionnaires applied in the research, Cronbach's alpha coefficient was used.

This coefficient was presented by Lee J. Cronbach in 1951. Table 03 presents the acceptable values, by range, for internal consistency verification [17].

Regarding alpha values, they vary between 0 and 1.0, and the closer to 1.0, the greater the internal consistency of the analyzed items [18].

Table 03: Internal consistency of the questionnaire according to alpha value

Alpha coefficient value	Internal Consistency
0,81 – 1,00	Almost perfect
0,61 - 0,80	Substantial
0,41 – 0,60	Moderate
0,21 – 0,40	Median
0,00 - 0,20	Insignificant
< 0,00	No agreement

Regarding high school, the study was conducted in three public schools, two in the municipality of Araranguá / SC and one in Balneário Arroio do Silva/SC. Since none of the schools offer computer programming as a curricular discipline, the resources were applied in semi-presential workshops (30 hours face-to-face and 60 distance at AVEA) of Introduction to Electronics, Programming and Robotics, taught in the school during the day. On-site activities were carried out by REXLab scholarship students and also by volunteer undergraduate students and the UFSC Postgraduate Program in ICT (PPGTIC) in Araranguá. They also assist in workshops at public schools, scholarship holders of PIBIC-EM. The practical activities were performed with electronics kits (protoboard, diodes, resistors, capacitors, various sensors, multimeters, soldering irons, etc.) and robotics (Arduino kits and parts and pieces built in 3D printer and Laser marking and cutting), plus tablets and laptops. All resources used were made available by REXLab. The activities already made use of AVEA IntecEdu, REXLab's virtual educational environment. Six workshops were held in 2018, 103 students participated and completed the activities. It should be noted that this was not a punctuated activity, that is, it did not have grades for any discipline and the adhesion to the courses was voluntary.

In higher education the study was conducted in a private institution, located in the city of Criciúma/SC/Brazil, during the 2018 school year and included students of the Information Systems college course, night time. The research subjects were students enrolled in the Management Information Systems discipline, related to the 6th phase of the course, and students attending the Systems Analysis and Design discipline, related to the 7th phase of the course. Being a total of 41 student respondents. To apply the research two exercise lists were created so that students could use the development environment of the remote experiment and the components available in Block.ino instances. Activity lists were named version "A" with six activities and version "B" with five activities.



#### IV. RESULTS AND DISCUSSION

The questionnaire applied to high school students sought to evaluate the satisfaction regarding the use of remote laboratories in the lesson plans by the students. Ninety-six high school students (93.2% of the total number of participants) answered, during 2018, from three public elementary schools in the municipality of Araranguá / SC.

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Figure 05 graphically presents the mean score values for the four scales evaluated.

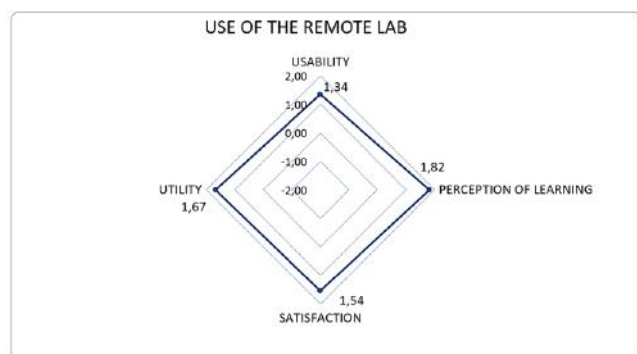


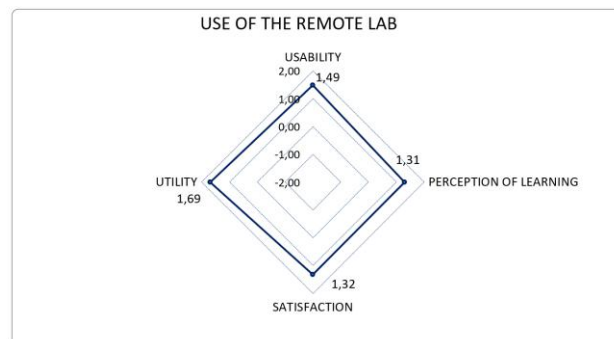
Fig. 05: Scores for the domains assessed, Higher Education.

Source: Authors.

From the questionnaire applied to the students of the Higher Education Information Systems course, based on the four domains explored in the questionnaire. Cronbach's alpha coefficient covering the 24 items of the questionnaire, including the four defined domains, presented a coefficient of 0.89 (Internal consistency value "Almost perfect" according to Landis & Koch (1977)). Likert scale mean scores was 1.43 and the standard deviation for the mean of the items was 0.238.

Figure 06 presents the average scores obtained in the four domains defined in the questionnaire.

Fig. 06: Figure 06 - Scores for the domains assessed, High school.



Source: Authors.

For the domains individually analyzed were obtained: Learning Perception (average of items = 1.31, alpha = 0.87 (Almost perfect) and DV = 0.075), Satisfaction (average of items = 1.32, alpha = 0.85 (Almost perfect) and DV = 0.390) and Utility (item average = 1.49, alpha = 0.75 (Substantial) and DV = 0.360). The four domains were analyzed individually, all scores are above zero, reflecting positive actions regarding the use of resources. Regarding Usability, six statements were elaborated, and the Cronbach's alpha coefficient obtained was 0.69 (Substantial), the average of the items = 1.49 and Standard Deviation = 0.183.

For the perception of learning, six statements were elaborated. Cronbach's alpha coefficient obtained was 0.82 (Almost perfect) and Cronbach's alpha coefficient obtained was 0.67 (Substantial). 1.31 and Standard Deviation = 0.196. Regarding the Satisfaction subscale, six statements were formulated. Cronbach's alpha coefficient was 0.78 (Substantial), the average of the items = 1.32 and Standard Deviation = 0.30. Finally, for the Utility subscale, six statements were elaborated. Cronbach's alpha coefficient was 0.70 (Substantial) the mean of the items = 1.69 and Standard Deviation = 0.175.

By grouping the percentages presented in Figure 10 into DT + DP (Totally Disagree and Partially Disagree) and CP + CT (Partially Agree and Strongly Agree), excluding the percentages of No Opinion. The percentages obtained for CP + TC were as follows: 86.18% (Learning Perception), 86.76% (Satisfaction), 93.73% (Usability) and 96.34% (Utility).

Regarding High School performing the same type of grouping, the following percentages were obtained: 97.13% (Learning Perception), 90.68% (Satisfaction), 88.20% (Usability) and 96.06% (Utility). The values did not show significant variations and the percentages were

very significant in all domains. In relation to high school, it was found in the domain Usability the lowest average and the lowest percentage value in item # 3, which dealt with the internet connection and waiting time in line to use the resource remotely. For this item in high school 26.88% pointed out that the Internet connection and the waiting line hampered the experiment and 61.29%, who had no problems in this regard. In higher education these values were 14.63% and 82.93% respectively, it should be noted that the activities at this school level were also performed in the HEI laboratory.

## V. CONCLUSION

This paper aims to present the use of a remote laboratory for hands-on online computer programming introduction activities. The remote lab shown can reach all school levels. The resources and services provided by it can be applied from basic education to higher education. Experimental activity is one of the key aspects in the teaching and learning processes of computer programming disciplines and the sciences in general. If we address the lack of technological infrastructure in public institutions in Brazil, especially in basic education, it will be realized that they are not able to provide satisfactory environments for carrying out practical activities.

On the other hand, mobile devices such as smartphones allow access to creative information and activities anytime, anywhere. They also support global connections and potential to represent learning opportunities. And to fill even the gaps in infrastructure shortages. A favorable context thus arises and remote laboratories are a real possibility, as they are devices that can support experimental activities, and contribute significantly to the improvement of teaching and learning processes.

Validation was performed in two educational scenarios, with great potential for use (presential course in computing and basic education). In higher education were part of the assessment of night information systems classes. In basic education, the use of resources occurred with high school students, in semi-presence workshops introducing electronics, robotics and computer programming, which were held in the evening, and with voluntary adherence.

The results obtained in the evaluation of use satisfaction by the potential users of the platform demonstrated the feasibility of reapplying the use of the remote laboratory Block.Ino in similar or even different contexts. Also, it indicates favorable platform scalability. Factor favored by the fact that its development is supported by open educational resources, free software and open hardware.

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