Abstract

This article partially presents the learning action proposed by the Learning Content Group of the Laboratory e-labora. The objective of the learning action is to serve as concept proof of the distance-learning environment under development in the TIDIA-Ae project. The topic of Introduction to Environmental Comfort was selected as the main theme of the action proposed for undergraduate students of Architecture. The corresponding distance learning course developed for the action is concerned in introducing students to elementary notions on the topic through observation and experimentations associated to practice. In this context, two infrastructures of Remote Access Laboratories (RAL) were used: the RAL-SIROS for an experiment on built environment evaluation on accessibility and the RAL-REAL for an experiment on ventilation evaluation on scaled model. This article discusses the necessary interdisciplinary effort for the mapping of present laboratory experiments to RLAs. It is also presented the validation process of the proposed experiments and the corresponding implementation in RAL format.

1. Introduction

The e-Labora Learning Content Group initiated its work on March 2005 with the objective to transform
the Learning Activity developed during the previous year, by the Task Group 3, into the concept proof of the TIDIA-Ae environment. The concept proof should provide subsidy for the redesign, if necessary, of tools and interface of the environment, in order to support the dynamics of the distance teaching-learning process conceived by the group. Formed by professors and researchers from various areas (civil, computer, electrical and mechanical engineering, architecture, computer science, pedagogy and linguistic), the group chose as subject for the Learning Activity the topic of Introduction to Environmental Comfort directed to undergraduate students of Architecture.

The theme Environmental Comfort is a relevant topic in the formation of future architects and civil engineers. A good functional behavior of an environment depends on the building quality, an adequate disposition of its equipments and the cooperation between users.

Architectural solutions must consider multiple factors, which affect comfort in accordance with climate and cultural characteristics. Therefore, it is desirable that students learn to specify environmental comfort requirements referent to: thermal, visual, acoustic and functional aspects. It is important for students to develop a refined perception capacity in order to be able to understand from a practical as well as a theoretical view the functioning and impacts of environmental comfort requirements.

The corresponding distance learning course developed for the action is concerned in introducing students to elementary notions on the topic through observation and experimentation associated to practice. This is the main reason for the development of individual and collective student activities supported by Remote Access Laboratories (RALs). Two existing RALs were adapted for this course: the RAL-SIROS adapted for built environment evaluation on accessibility and the RAL-REAL adapted for ventilation evaluation on scaled model. SIROS [7] and REAL [1,2,3] are research projects of the NIED/UNICAMP and CenPRA-FEEC/UNICAMP respectively.

The distance course is directed to Architecture undergraduate students of the three public state universities of São Paulo (USP/EEESC, FAAC-Bauru/UNESP e FEC/UNICAMP). The participants must be studying from the second semester of the first year to the second semester of the second year of the architecture course, period in which environmental comfort is introduced in the formal curricula.

Due to the schedule of the TIDIA-Ae Project, the course was designed for a 30 hours term, distributed in 6 weeks. The course is being offered in the period of September 5th to October 21st, 2005. The course counts with the participation of professors, specialist in environmental comfort, from the three public universities above indicated. These specialists participate in synchronous discussions. The theoretical content planned follows the organization presented in Table 1.

This article discusses the necessary interdisciplinary effort for the mapping of present laboratory experiments to RALs that involve concepts of thermal and functional comfort. The migration from present to distance education demands a collaborative work of various specialists oriented by an education perspective. Such education perspective must considered fundamental aspects as: the learning context of contents and know-hows, the quality of interactions between participants of an educational-learning scenario and the reflexive process, which promotes learning [5].

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<th>Table 1. Course schedule</th>
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2. The educational approach

The Learning Content Group of the e-Labora sees the WEB as an important space for the co-production of knowledge and know-how. A characteristic of this type of education and learning is in the potential of the creation of an active net of learners with common interests, which aims to facilitate the circulation and appropriation of knowledge, educational and cultural practices. This means that beyond the technology for distance education and the thematic relevant for the area of formation; the development of a method compatible with the education objectives is fundamental for success.

In this methodology special relevance is given to the choices made in terms of distance education.
environment tools. Because such choices guarantee the theoretical perspective intended by the teacher(s) of the course, and therefore, influence the quality and dynamics of the proposed Learning Action [5]. All stages of the Course were meticulously discussed and documented by the e-Labora Content Group; with the objective to specify adequate tools for the realization of each week of the course schedule, considering the specification of the theoretical content approached and the aimed public.

Thus, the total planning of the Course went through various stages (between March and September, 2005), requiring continuous adjustments between the TIDIA-AE Project schedule, the nature of the theoretical content (Environmental Comfort) and the educational approach which orients the intended teaching-learning practice. One of these stages was the design of the activities involving the use of RALs.

The experiments have a fundamental importance in our methodology, reason for which RALs were adopted. The student understanding of certain Environmental Comfort requisites – specially those related to natural ventilation (thermal comfort) and accessibility (function comfort) in a building – can benefit from manipulation, exercising and use. From the learning point of view such activity propitiates a reflexive exercise that involves surveying and the verification of hypothesis. The theoretical knowledge that supports an activity like this gets more life and meaning since it can be put to work, tested and rearranged, what favors the establishment of new connections with other subjects. [6]. Besides that, the result of one student activity can be compared, discussed and criticized by his/her peers and professors: everybody can share their experiences and solutions, leading to an extremely productive effect on the learning process [5].

The experiments on environmental comfort performed on Remote Access Laboratories also counted with the collaboration of a group of post-graduated students on Civil Engineering, Architecture (FEC), oriented by Professor Doctor Regina Coeli Ruschel and researchers from SIROS laboratories (NIED) and REAL (CenPRA-FEEC), both members of e-Labora group.

3. Experiments validation and RALs

Remote Access Laboratory (or simply RAL) are actual equipments that can be operated and controlled remotely by a graphic interface usually using the Internet web as way of communication. This kind of laboratory eases the logistical and infrastructure needs compared to the functioning of a standard laboratory such like booking the equipments and installations space usage, professionals scheduling to accompany students’ activities. From the educational point of view, something important to be mentioned is the freedom students have to conduct their experiments from any computer connected to the WEB at the time that most please them: the learning process may happen according to the student rhythm and time availability [7].

Following we present the RALs adapted for the functional and thermal experiments developed for the Learning Action. We will first present the architectural design concepts and teaching approach related to the environmental comfort introduced. Next we describe the experiment proposal, its validation process and the correspondent RAL used for the experiment implementation.

In the case of the RAL implemented by the SIROS Project adapted for the functional comfort experiment, besides the experiment validation, we also present the results of the pilot offering of the Learning Action, that took place in September 2005.

3.a. Function Comfort: accessibility

Functional comfort studies help designers mainly during the pre-design stage of a building. This stage not only demands the specification of minimum measures of spaces for the execution of determined task, but also embraces the whole architectural program of the building. At this moment, volumes, the accesses, the geometry of the spaces, the configuration of the openings, the framing in the land, among other factors must be defined. The evaluation of the functional comfort in a built environment uses, as parameters, the relations of proximity between environments, the accessibility and the flows that will be used more, the availability of useful area per user, the ratio between the external and internal spaces, the anthropometrical characteristics and the equipments to be used by the users [10].

Seven principles of Universal Design (UD) provide parameters of functional comfort guiding a project that aims for a lifetime building, that efficiently takes care of the necessities of all users, in any situation. These seven principles of UD are: equitable use, flexibility of use, intuitive use, perceivable information, tolerance to the error, low physical effort, size and space for access and use [8].

Taking these principles as evaluation parameters we developed an experiment in the context of accessibility performance evaluation of built environment. The experiment involves the visitation of an existing building and the photographic register of
restrictive situations of accessibility encountered. This visitation is made remotely by a robot controlled by the Internet that captures images of the place and takes photos on the participant demand.

The space chosen for the exercise of accessibility performance evaluation of was the ground floor of the building of classrooms of the college of Civil Engineering, Architecture and Urbanism of UNICAMP. The experiment is developed individually: each student leaves starts his/her visit from a different point of the building. With photographs extracted during the visitation the each student writes a report guided by the seven principles of the UD. These evaluations of the building are partial, because students end up making free tours with some overlap between them. The global evaluation of the space is generated from the sharing of information and a general discussion.

The experiment validation occurred in May 2005. The validation process wanted to verify if: (i) the adaptation of RAL developed by SIROS project supported the experiment, (ii) if the remote control of the robot imposed restrictions in the visitation and (iii) if the photographic registers, supplied by the robot, would allow correct perception of the built environment and subsidy an evaluation performance report.

We verified that the implemented adaptation of RAL, developed by SIROS project, supported the requirements of the functional comfort experiment. Although the movement controls of the robot allow remote visitation, we observed the necessity a local accompaniment (a person) of the robot during the remote controlled tour. The participant may place the robot in a certain situation where its physical removal is necessary. We also verified the necessity of another video camera to show the robot visiting the environment. This second image, was called experiment sight in the second person, would help the remote participant to locate himself/herself better in the visited space.

We also observed that the height of 40cm of the robot camera could give the participant a wrong perception of size. For example, a parking delimiter of 30cm of height can seem, in the image captured by the robot, as a guard body. Therefore, we find convenient to change the height of the robot camera, or keep a constant frame of reference during all the passage (for example a person in the direction of the robot’s view). Another possible solution for this question is the implementation of an extra camera control in order to change the view about 10 degrees up or 10 degrees down.

Project SIROS team uses low-cost hardware and software technologies that can be implemented in laboratories from basic to superior educational institutions. In this way, the constituent parts of RAL-SIROS were built obeying to the criteria of modularity and portability, in order to facilitate RAL mobility, that is ease in RAL’s installation in geographically distinct places from the laboratory it was created.

For the RAL-SIROS installation it is enough to have a computer with access to the Internet, the RAL-SIROS programs of communication and the robotic device. The communication with the robotic device is made by means of a radio link. The graphic interface of the RAL-SIROS offers buttons that allow: to move robot forward or backwards (reverse speed) in steps of 30cm; to turn right or left in increments of 20 degrees. Moreover, the interface has buttons that allow controlling the robot video camera (look up, look forward, look down 10 degrees) and to take and save photos. The stored photos can later be recovered and are sent by email to RAL users (this task is not automatic). To access RAL-SIROS the user needs just a computer with access to the Internet.

To allow the remote visiting to the environment a mobile robot was developed using a low cost educational interface [9]. The interface presents a resource to control three engines and communicates with the computer by means of radio frequency link. Two engines are connected to the base and the wheels to allow the displacement. One third engine was connected to a video camera in order to allow its movement in the vertical direction. A transmitter hardwired to the video camera sends signal that are captured and displayed in the computer screen. Figure 1 presents the mobile robot and its components.

![Figure 1. Mobile robot](image_url)
text notations. The described functionalities are displayed to the user from a graphical interface, as is shown Figure 2.

![Figure 2. Graphical interface for controlling the mobile robot](image)

The experiment of functional comfort implemented in the RAL-SIROS was used by students during the pilot offering of the Learning Action (on the 23th of September of 2005), which added new knowledge to the experience, beyond those obtained in the validation process. We observed the necessity of synchronous communication with the remote participants during his/her tour. We verified instabilities in the used technology – interference of communication in radio link – and reach the limit of the resources offered in terms of net speed and robot autonomy (distance and battery).

The camera sight in second person was not implemented in the RAL-SIROS, reinforcing its need, for participant demonstrated difficulty in locating themselves in the studied environment. We assume that a return for the participant to trace the covered way can help them to correctly locate the robot during the remote visit to the environment.

We also observe that even with the pointed difficulties – existing in greater or minor frequency in all sessions of the RAL – some students reached a better performance in the remote visitation than others. We raise as hypothesis – for future proof – that the students who transpose the interface and project themselves remotely in the place of the robot in the visited environment, have a better performance in this type of RAL.

We evidenced that even with the limitations found there was: (i) great satisfaction of the students in participating of the experiment and (ii) that the experiment proposed to performance evaluate environment in terms of accessibility using RAL is absolutely viable. We notice that remote visiting of an existing site presents certain limitations and it does not substitute the real experience. However, it allows the visitor a differentiated look on the environment, what requires a certain abstraction of the perception processes, similar to what occurs in the act of architectural design. These comments were made by the participants themselves of the RAL and by environmental specialists that participated in synchronous discussion (chat) after the experiment. We can, therefore, conclude that the real (being present) experience and the remote experiment are complementary processes, both reach in learning resources for the evaluation of accessibility requirements.

3.b. Thermal Comfort: natural ventilation

The thermal comfort of an environment is essential for the sensation of welfare and the good development of the activities to be executed in it. Discomfort situations caused for extreme temperatures, insufficient ventilation, extreme humidity combined with raised temperature, thermal radiation due to warm surfaces, can be sufficiently harmful, causing sleepiness, alteration of cardiac beatings and increased perspiration. The parameters that will have to be analyzed for an environment thermal comfort evaluation are: temperature, ventilation and air exchange, incidence of solar radiation in the constructive elements, people direct exposition to solar radiation, relative humidity of the air, mildew and deterioration of building materials, activity exerted by the users and vestments used [10]. One of the aspects related to the thermal comfort in a building in regions of tropical climate is the natural ventilation. The natural ventilation in the interior of a buildings is influenced by its orientation (implantation with relation to the magnetic north), by its existing openings (doors and windows) and by the predominant wind of the region.

In this way, we developed an experiment having as dependant variable the way the air flows in a reduced model being influenced by the independent variables: orientation of the model front (north, northeast, east, southeast, south, southwest, west, and northwest), combinations of opening/closing of windows and doors and the southeastern predominant wind (representing the region of Campinas – SP). To allow the visualization in plant of the ventilation in the interior of the model, its roof was substituted by a transparent plate.

The architectural project chosen for the experiment represents a standard house, also of the region of...
Campinas – SP, existing in neighborhoods of self-built houses and land divisions of social interest habitation [4]. With this experiment the designer can verify which orientation of the project implementation in the lot will imply in better conditions of thermal comfort associated with the natural ventilation, being able, for example, to influence in the drawing of the land division where this project will be multiplied.

This experiment is an innovative procedure in architectural design education and environmental comfort. It is possible nowadays to make ventilation simulations on scaled models in wind tunnels. Wind tunnels allow the study of ventilation between models and inside models up to 1:50 scale. In some cases, depending on the size of the project, it is impossible to insert the complete model inside the wind tunnel in scale 1:50. Thus, it is necessary to execute partial studies and afterwards combine results. In the experiment here described, the study of ventilation inside scaled model bigger than 1:50 is allowed, including the use of automation. However, this experiment does not substitute wind tunnels simulations, but complements it, allowing one use in education that foresees contribution and sharing, enhancing the learning process.

In June 2005 validation tests of the experiment, still without automation, were carried out, in order to study future possibility of a corresponding RAL implementation. In the tests we search to verify: (i) which source of wind is more appropriate for the experiment (hair dryer or fan); (ii) if ribbons of video cassette on the passages of the openings are the appropriate material for marking the air flow; (iii) if the static images of the experiment (photographs) show the air flow indicated by the ribbons and (iv) if these registers of the ventilation allow edition for overlapping with the architectural drawing, making possible, in this way, comparisons among multiple orientations of the project.

We verified that the hair dryer is more appropriate for the scale of the experiment and desired simulation of wind. Although the video cassette ribbons on the opening passages efficiently mark the air flow, they restrain the automation due the necessity of being reorganized at each multiple opening / closing of doors and windows. A new solution for marking the wind flow will have to be considered.

We noticed that the static images are efficient registers of the ventilation in the interior of the model, however they need high resolution for a precisely identification of the possible air flow. The continuous register of the experiment, with sound, has an important role for the student considering the remote execution of the experiment. With image and sound recording of the session, or parts of it, the student can review his/her on-line results of combinations of door and windows openings over the natural ventilation inside de model and better express themselves in the written reports.

We developed a graphical schema for visual comparison of the ventilation registers in the eight orientations studied for the house implantation, to support the identification of the best and the worst orientation according to the natural ventilation (Figure 3). In the left side of Figure 3 images registered in the experiment mark the air flow with ribbons and in the right side of the same Figure the observed air flow is represented in drawing format over the architectural plan of the house. The empty pictures represent orientations of the model that were not tested.

An experiment above described was implemented using the REAL Project infrastructure and this RAL experiment was named REAL-TC. The REAL Project (Remotely Accessible Laboratory Project) [1, 2, 3] started at the Renato Archer Research Center (CenPRA) in 1996 and since 1997 is driven by a joint cooperation between CenPRA and FEEC/Unicamp. The objective of the project is to provide remote access to the mobile robots lab of the CenPRA’s Robotics and Computer Vision Division. Current version of REAL employs Web Services, Java Server Pages (JSP), and software components at the server side, with client-side access based on web browsers or desktop java applications launched via web browser. In REAL, every lab component is exposed as a Web Service. The robots, cameras, access control, logging facility, etc, are Web Services with public WSDL (Web Service Description Language) interfaces. In this way, it is possible to configure robotics experiments by composing different Web Services.

REAL allows the user to perform different experiments at different levels of complexity. Simple
experiments execute pre-programmed actions (e.g., tele-operation, random walking, and obstacle-avoidance walking). Intermediate complexity experiments include the composition of pre-programmed actions, for instance, environment mapping combined with path planning for navigation in unmapped environments. High complex experiments include the designing of new actions (e.g., navigation based on real-time video processing), uploading of user-supplied control code on the internal robot processor, and experiments on cooperative robotics.

The architecture of the REAL-TC experiment is considered of simple complexity, as defined above, and employs three horizontal layers: presentation, logic and service layers. The presentation layer runs at the client side and is based on HTML forms and Java scripts. The logic layer employs a Linux server running the Apache Tomcat web container supporting JSP that process the client requests. The service layer employs another Linux server running the Apache Axis Web Service container. This server controls the robots, the panoramic camera, and the remaining lab equipments such as positioning servos, on-off switches, etc.

REAL-TC uses the modules of REAL and adds a new module that will be incorporated in the robotic infrastructure due to its generality. The three modules are the robot module, the panoramic camera module, and the new servo-positioning module. The robot has as its load a scaled model of a simple house. The robot turns in steps of 45 degrees in order to expose the model to a source of air flow (wind) from different angles (representing house implantation to north, northeast, east, southeast, south, southwest, west and northwest). The methods related to robot movements in the robot WSDL interface are employed for this task.

A panoramic camera allows the remote student to inspect the air circulation (marked by the tapes inside the model), take a snapshot, and record a movie of parts of the experiment. The methods exposed by the WSDL interface of the panoramic camera module perform such operations.

The control of windows and doors in the model are remotely controlled in pre-configured sets and as well as the tuning on and off the fan (air flow). A new module named the servo-positioning module, controls up to eight positioning servos and on-off switches. This module also exposes a WSDL interface that allows a client program to select a servo or switch and operate it.

Figure 4 shows the user interface for the REAL-TC experiment. The leftmost frames allow the user to position the model with the robot turn and to select different combination of doors and windows openings as well as to turn the fan on and off. The rightmost frame allows the user to operate the panoramic camera by controlling the pan/tilt (X-Y axis) zoom in and out, snapshot, and movie recording. The middle frame displays the image from the camera. The bottom frame presents status information (user, remaining time, etc.).

4. Conclusions

We verified the necessity of an interdisciplinary effort to delineate the experiments to be carried out in the Remote Access Laboratories. Such effort involves specifying: the kind of interaction allowed, roles attribution, group and individual session organization, interface design and the kind of experiment data generated. In the same way, equal effort is necessary for the methodological conception of the experiment inside the learning action: elaboration of a detailed activity guide (what is expected from the student), development of support materials, type of description / analysis in format of reports, organization of discussion groups, reading and commentaries about colleague activities, etc.

We observed that activities that make use of Remote Access Laboratories do not substitute – at least to what concerns the subject of Environmental Comfort – eminently practical activities in the real world, but they have an important complementary role.

The e-Labora Learning Content Group developed, throughout its performance, a methodology for elaboration of applications in the target area of Environmental Comfort, which foresees: (i) elaboration and validation of actual activities with specialists in the subject and the technology area, (ii) pre-tests of these activities, (iii) students effective use of the activities. Only after this evaluation cycle it can be assumed that the Remote Access Laboratory presents the necessary conditions for the accomplishment of the activity in question – delineation of the variables to be studied, type of
interaction, interface, kind of reply, feedback to the user, among other aspects—and only from this moment on it is possible to be considered alterations of content and/or expansions of the original activity.

5. References


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