

# Experimental Laboratory for Teaching Architecture Lighting in a Virtual Learning Environment

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**ABSTRACT:** Daylighting considerations influence the whole design process and incorporate as many conceptual and aesthetics topics as technical ones. In spite of research results and technology advances having occurred in last decades, one can notice that there are several barriers turning difficult its integration to the architecture design. One can believe that the main factor for this reason is the lack of adequate comprehension of daylighting phenomenon. This research presents the development of a Virtual Learning Environment (VLE) for promoting the student's comprehension about the lighting phenomenon, approaching the light path and its modifications generated by the main architectural design variables.

Keywords: Lighting, Virtual Environment Learning and Analytic Model.

## 1. INTRODUCTION

Buildings can be considered as a filter between users of internal spaces and the external environment. They must be effective to control thermal, lighting and acoustic aspects. Beyond the great importance of the climatic questions, the architecture is not only the search of a shelter solution; it also assumes a symbolic question through full elements of meanings, as for example, the topological situation of the building, its formal characteristics, its effect when interacting with light, the colour and the texture.

Studies about those elements forming the space (in functional and symbolic terms) are essential for Architect's formation.

Abilities and know-how in manipulating daylight were considered essential when we had access to the artificial light, nearly 1900 [1]. The daylighting domain in architecture was defined throughout the development (welcome) of artificial sources of light with accessible costs. Many professionals consider the use of daylighting like one little element or no importance one [1].

Currently, usual spaces are badly illuminated and the consequence about this is the harming of the visual activities in the majority of the buildings [1]. Despite the advance occurred last decades in research and technological tools presented through scientific publications, one can note that there are barriers that hinder the daylighting integration on architectural project in a satisfactory way [8]. This panoramic is a consequence of the main difficulties that architecture imposes to the integration of the daylighting in the design: the understanding of the phenomenon and related aspects [8].

An alternative to revert this process is to create procedures that include as much the professional

formation as acting professionals in the market. The object of this research is to act in the source of the formation and professional update. It is important to know that there are traditional methods of education as well as innovative ones. The use of promising technologies for education, as the Internet, have advantages and disadvantages regarding the traditional method. On this way, the current work takes advantage from a virtual environment. This proposal can be applied either on actual education or in a long-distance education in accordance to each ones learning rhythm and time availability.

The proposal consists of creating and developing a Virtual Learning Environment (based on a Learning management system) aiming to facilitate the knowledge of the daylighting phenomenon. Virtual Learning Environment can be defined as a virtual space managed by a set of tools that mediates the learning processes, where content and activities are organized and put available to the students and teachers. VLE represents a new media in evolution, offering an original way of organizing information and the way of learning.

## 2. VIRTUAL LEARNING ENVIRONMENT

The Virtual Learning Environment proposal will be inserted in the AVA\_AD system, that means in English Virtual Learning Environment for Architecture and Design. The AVA\_AD has been developed under the coordination of the PhD Alice T. C. Pereira at the Hypermedia Laboratory of the Federal University of Santa Catarina. AVA\_AD can be understood as a set of environments that contributes for the student's learning process about symbolic and functions elements that structure the real built space.

Some difficulties appear from the technological point of view; due to the need of interacting with a sort

of graphical elements. There are contents that must be visualized in order to be perceived and understood. This can be facilitated through the use of graphical software and, also, by Virtual Reality environments.

With the main objective to stimulate knowledge construction and to result in a success learning experience, this environment offers a rich gamma of collaborative tools, such as chats, forums, and also 2D and 3D collaborative graphics tools. The use of images, animations, videos and navigation in virtual three-dimensional worlds consists of some possibilities offered by the AVA\_AD..

As a way of evaluating students' knowledge, a set of exercises and problems follows the development of the content. The Problem Based Learning (PBL) method is applied to motivate students' active posture in approaching the learning process. This method presents a problem in a first moment in order to direct students way through the contents of the module, making the inverse way of the traditional learning. The elaboration of these problems should be planned using different deepened levels and the development must be of collaborative character, making possible quarrels and exchange of knowledge among students.

## 2.1 Light Module

The theoretical section of the Light Module searches integration between the conceptualization of the physical behaviour of the light with its use in the architecture. It is approached contents on the light and its relation with the human system eye-brain in terms of physiological and psychological human beings reactions; studies on how daylight were used in architecture in elapsing of the civilizations history in accordance with the climate and the culture of the diverse regions of the world; comparisons between natural and artificial illumination, describing the importance of the daylight in relation to environmental comfort and energy efficiency on the construction; photometric largeness - such information assist in the quantification of the light; specification of optics properties of materials; selection of conduction components and elements of radiation control, etc.

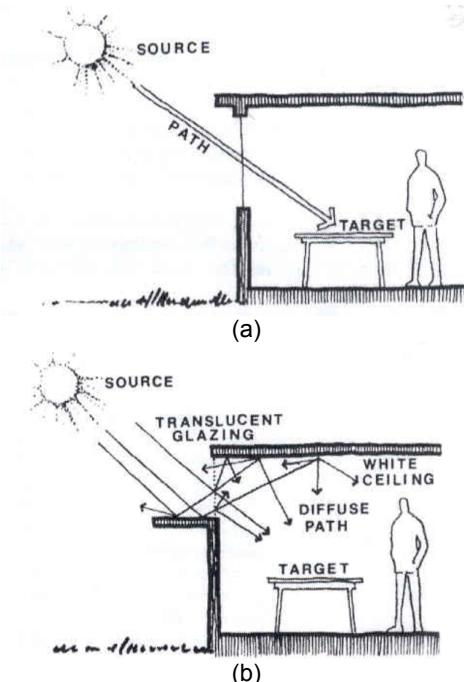
Besides providing a theoretical base through contents, the Light Module counts on a tool called Laboratories of Light to aid learning and problems resolution. Currently the first laboratory is implemented, another one is in implementation phase and third one is the theme of this article.

## 3. PROPOSAL LABORATORY

Beyond the function of integrating theoretical and practical issues, the laboratories main objective consists of contributing for students understanding the illumination phenomenon in architecture. To reach this objective was used an Analytical Model as reference, provided by Moore (1991) [5].

### 3.1 Analytical Model of Reference

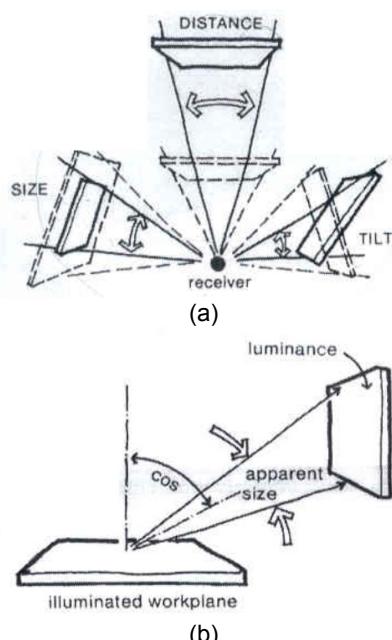
Analytical Model is defined as an idea, opinion or image that can serve as example for posterior reproduction. This model objective is to explain the illumination phenomenon through a project representation, involving the source of light, the trajectory of this and the desired target. The localization of the source and the target is determined and the direct or indirect trajectory can be described and be planned [5].



**Figure 1:** Analytical Model using Source-Target-Path for explaining examples of direct light (a) and diffuse light (b). Source: MOORE, 1991 [5].

Using the traditional way of light representation on project for showing diffuse path can be bring problems. The route of the light can create a confusion of "arrows" (to see figure 01b), the alternative is to consider the illumination as resultant of brightness areas that can "be seen" by the target or receiver. This concept does not differentiates the nature of some sources types; in this way, a cloudy sky or a white wall, with equal luminance, colour and apparent size, should give a similar contribution for the illumination on receiver [5].

The potential of a surface (source) illuminating a determined target, can be previously foreseen through the product of its luminance and its apparent size (figure 2a). The apparent size of the source seen by the receiver is determined by the size, distance and tilt of the source relatively to the receiver. In this way, a larger source size, a minor long-distance of source to the receiver and a minor angle between the normal of the source and the direction to the receiver, greater will be its apparent size.



**Figure 2:** Apparent size of distributed source is a function of size, tilt and distance (a) and illuminance of a reference plane as a function of distributed source luminance X apparent size X position. Source: MOORE, 1991 [5].

Another important factor that influences the results is related to whether the receiver is a surface, then the position of the source in relation to the receiver must be considered (figure 2b). With a source accurately above of the surface (parallel to this) the illumination is maximized, but in case the position is oblique then will occur a reduction called "cosine effect". As bigger the angle between the source and the normal one of the surface, greater will be the cosine effect and larger will be the decrease of the final iluminância [5].

On this way, the illumination produced in a surface, becomes the product of luminance, apparent size and position of the source in relation to this surface.

This way to understand the illumination will serve as analytical model of reference in the virtual laboratory of experimentation, as follows.

### 3.2 Navigation Path

The proposed Laboratory is structured in two parts. The first one consists of the Analytical Model, presented previously as main methodology of education that will be discussed with more details in the next section.

The considered virtual environment is made for daylighting education, focusing the desired effect on the building or planned space and the necessary techniques for such, follows a gamma of solutions dependent on the architect creativeness, determined by practical experience and case studies.. Based on these premises, the second part of the virtual learning environment will possess three main ways of navigation: one through the desired effect in the project, another one through the technique/engineering/science necessary to acquire

such effect and, finally, through pictorial repertoires with the real and virtual examples for setting and understanding of the phenomenon. Beyond the real examples, it will have links for the two existing laboratories already in the Light Module.

The two first forms of navigation - effect and science - will possess a content of introduction to the subject. After that, both ways are joined in the experimental analytical model. The purpose of this part of the navigation, through content and experimentations, is to explain the analytical model of reference adopted. After this stage, the ways go apart again so that the experimental laboratory follows the specific aspects of each interest. This laboratory possesses side integration between the two chosen ways and the repertoire based on existing examples, which are important to be told by its relevance. Beyond these examples, the two laboratories of the AVA in implementation phase will be incorporated as repertoire of the environmental bred (figures 5 and 6).

**LABORATORY OF LIGHT MODULE**

**Introduction**

The Laboratory of Light Module is a VLE estruturated in some parts that it possibilities the student understand the Daylighting phenomenon on Environment Builted.

The Laboratory approach the phenomenon on gradative way, involving the main architeconical variables that influentiate through simple models until the architeconical complex with set of surfaces.

It knows that the lighting on a point determined depends of three factors:

1º Source Iluminance	2º Apparent Size of surfaces enveloped on relation of target	3ºCosine Effect
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The Laboratory focuses the three questions about course content. The environment estruture is dived in two parts, as you can access below:

1º PART:

**ANALYTIC MODEL**

2º PART

VISUAL EFFECT
SCIENCE
DATABASE OF MODELS

**Figure 3:** First part of the Proposal Laboratory. Source: ATANASIO, 2006 [11]

The proposal laboratory is based on the analytical model of reference planned in a interactive way as a type of small simulators of effects, enabling quantitative and qualitative analyses. "Illumination is as much art as science" ; that is, daylighting is considered as an element of designing language and, also, an environmental system. As design element, it can favour the building in terms of qualitative and aesthetic aspects. As environmental system, this must be subjected in the same level of rigorous analyses and revision of any environmental system..7] ".

#### 3.2.1 Experimental Analytical Model

This part of the proposal virtual learning environment aims to explain the analytical model adopted and to carry through some virtual experiences. These experiences are based on actual laboratories experiences.

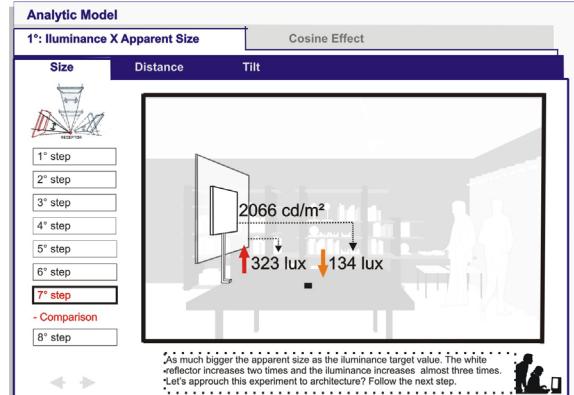
In accordance with the Moore's model, the student will be able to observe the phenomenon through

effect modifications in computer simulations models, and, referring to the relation of cause and effect in the architecture. The virtual environment as a whole will be a simulator of daily established situations.

The proposal laboratory for the analytical model focus two parts related to the two of the three factors that determine the illumination in one specific point: the apparent size and the effect co-sine. These two variables are treated separately. First of all, part one remains the effect co-sine and the luminância of the form source that only the apparent size modifies the result in the target (figures 6, 7 and 8). In the same way the apparent size occurs in the second part keeping always constant (figure 9).

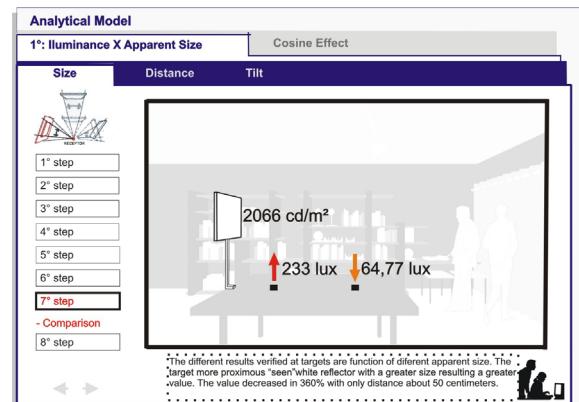
For both ways, an interface was developed alike. The student can navigate following the steps specified in the left menu. Following the steps, the user chooses between two options of comparable experiments, visualizes the related simulation and results. After that, he carries through the same for the second option. Finally, he visualizes in the same screen the result of both choices and, after that, he observes examples approaching the experiment of the architecture through basic images. The screen is standard for all the experiments modifying only the objective of these. The user can use the virtual aid that directs the study in the present icon on the under part of the screen.

#### Size:



- 1 - Chose the smaller plate.
  - 2 - Visualization of the image obtained by simulation
  - 3 - Analysis: Plate's luminance Target's illuminance
  - 4 - Chose the bigger plate
  - 5 - Visualization of the image obtained by simulation
  - 6 - Analysis: Plate's luminance Target's illuminance
- 7 - Comparison**
- 8 - Chose to visualize examples to experience the effect** for settling theoretical contents and decide the approach to the architecture design..

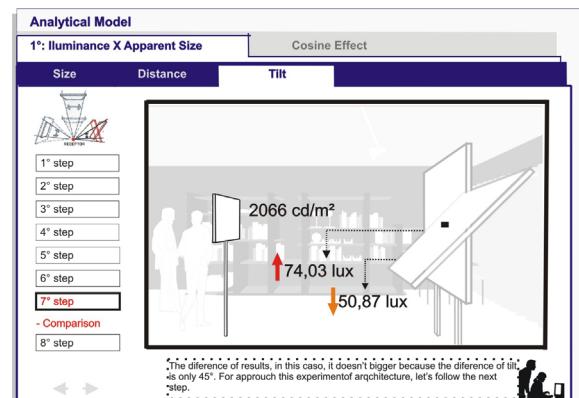
**Figure 6:** Luminance/Illuminance X Apparent Size - Size. Source: ATANASIO, 2006 [11]



#### Distance:

- 1 - Chose the most near plate moved away from the target.
  - 2 - Visualization of the image obtained by simulation
  - 3 - Analysis: Plate's luminance Target's illuminance
  - 4 - Chose the next plate.
  - 5 - Visualization of the image obtained by simulation
  - 6 - Analysis: Plate's luminance Target's illuminance
- 7 - Comparison**
- 8 - Chose to visualize examples to experience the effect** for settling theoretical contents and decide the approach to the architecture design.

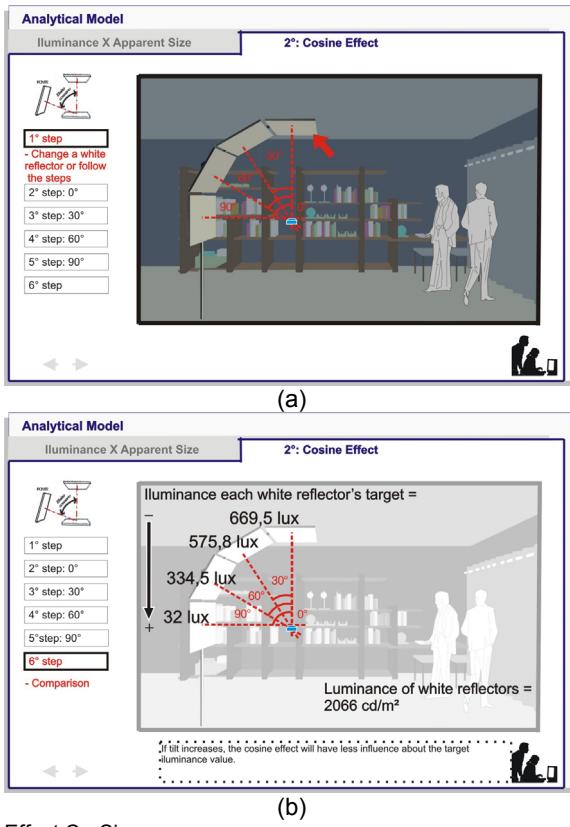
**Figure 7:** Luminance/Illuminance X Apparent Size - Distance. Source: ATANASIO, 2006 [11]



#### Tilt:

- 1 - Chose the less inclined plate.
  - 2 - Visualization of the image obtained by simulation
  - 3 - Analysis: Plate's luminance Target's illuminance
  - 4 - Chose the more inclined plate.
  - 5 - Visualization of the image obtained by simulation
  - 6 - Analysis: Plate's luminance Target's illuminance
- 7 - Comparison**
- 8 - Chose to visualize examples to experience the effect** for settling theoretical contents and decide the approach to the architecture design..

**Figure 8:** Luminance/Illuminance X Apparent Size - Inclination. Source: ATANASIO, 2006 [11]

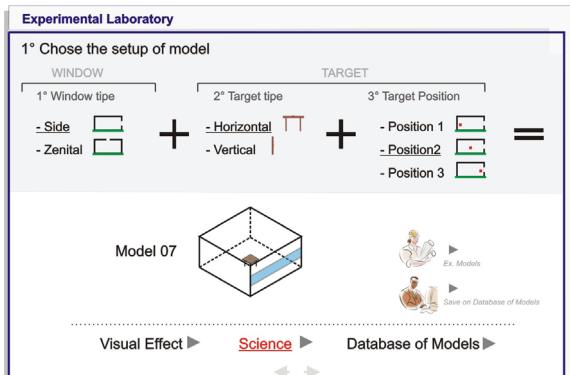


- Effect Co-Sine:**
- 1 - Chose the perpendicular plate to target (a)
  - 2 - 0°
  - 3 - 30°
  - 4 - 60°
  - 5 - 90°
  - 6 - Comparison (b)

**Figure 9:** Effect Co-Sine. Source: ATANASIO, 2006 [11]

### 3.2.2 Experimental Laboratory

The second part of this proposal refers to the inclusion of daylighting and its complexities. This is placed posterior to the first part because the involved variable data about the phenomenon needs to be seen step by step.



**Figure 10:** Model choice from opening type and target (a). Source: ATANASIO, 2006 [11]

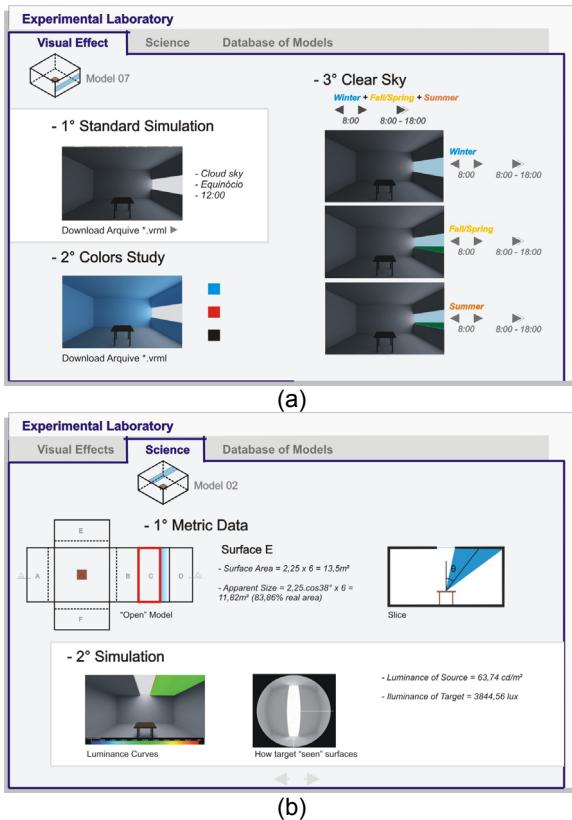
The navigation occurs from the choice of the desired model (figure 10). The user must choose three elements individually that added the result in the final model: zenithal or side opening, target horizontal line or vertical line and position of target number 1, 2 or 3.

After model choice, the interface offers three options: visual effect, science or database of models. Each one of these environments is in accordance with the chosen model and can be visualized from the concept point of view of each one of these three ways.

The first one of the three possible ways is the comment of the visual effect of the chosen combination. The student can observe the image of the standard simulation (surfaces with a coefficient of average reflection = 0,4) obtained through the program Lightscape 3,2 and download the archive \* vrm - that makes possible the navigation in the model (figure 11a). Through this way, the analysis tends to be more complete because the vision of the 3D space. After that, analyses with regard to different colours of walls and ceiling and its results in effect terms can be proceeded. The code of colours means: a cold colour is represented with the blue one, a hot one with the red and the absence of colour is represented with the black. Only modifying this variable can change completely the effect.

The second part mentions the model data gotten through computational simulation (figure 11b). The first image presents the curves of gotten values of luminância through the simulation in the program Lightscape 3,2 regarding the chosen surface - analyzed here as source for the target in question. Beyond the image, the average value of plate's luminance in question, the value of illuminance in the relative target to this surface is available. Another image was gotten through the Apolux program through the tool vector photon. The image offers characteristics of a photo gotten through a camera with fish eye lens. The origin point is the target, or either, the observed image is related to the target way of "seeing" the surfaces. Through this image the apparent size of the surfaces in relation to the target can be evaluated.

The third form of navigation is through the Database of Models. On Database, four parts are available. The first one is related to the personalized database referring to the models saved by the student with the objective to have quick access to the model already analyzed. The second and third parts mention Laboratories 1 and 2 of the Light Module, still in implementation phase. Through the models, the user can do effective comparisons, due to the models have the same dimension varying only the characteristics of the openings and reflection of the surfaces. The fourth part of the Database Models consists of analogous real models to the model presented in Laboratory. On this place, images with information of the architect and comments for each one are made available. This is the way chosen to approach the primitive models with the real architectures.



**Figure 11:** Screen showing the visual effect (a) and science (b) with relation to the chosen model. Source: ATANASIO, 2006 [11]

#### 4. CONCLUSION

Regarding the described strategies in designing the Experimental Virtual Laboratory, the process of adequacy of the laboratories and existing contents in the Light Module brings greater integration to the proposal. The use of an analytical model of reference with an approach to architecture objectives has shown to be useful to fill a gap in the formation of the professional. Through the diversity of the presented models, in an interactive way and related to the method of analytical model, the proposal makes possible student to visualize the phenomenon of daylighting. Students can also identify how the changeable architectural influence the final result related to daylight through its visual effect as much as the scientific analysis of the phenomenon.

Through the suggested learning method, one expects to contribute for the students knowledge about the physical phenomena associated to the daylighting illumination. It is expected to make possible the construction of a students' solid base of knowledge and, consequently, a better exploitation of the daylighting on the architectural project.

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