



3D Design: Form and Light

Ms. Mary Ann Frank, Indiana University Purdue University, Indianapolis

Senior Lecturer, Interior Design

Beth Huffman, Indiana University Purdue University, Indianapolis

Beth Huffman is a lecturer at Indiana University Purdue University Indianapolis (IUPUI) in the interior design department. She is a licensed architect with specialties in sustainability and construction. Beth's classroom pedagogy is focused on the practices of design/ build. She often encourages students to build a portion of their projects at full scale, in order to understand construction connections and details.

Beth has her Master's of Science degree in Architecture from the Illinois Institute of Technology and her Bachelor's of Architecture degree from Ball State University. Additionally, she continues to practice architecture through her own company, Muse Design. She enjoys the synergistic relationship between her role as a professor and her role as an architect, and believes that this hybrid provides real world practicality into the classroom on a daily basis.

3-D Design: Form and Light

Abstract

This paper describes method and evaluation of pedagogical experiences in 3-D design. At IUPUI, design students learn properties of form utilizing 3-D design methods of structure and aesthetic properties. This experience combines structural learning methods with 3-dimensional properties of light quality and distribution during two consecutive course terms. Students design and build a full-scale suspended luminaire to suit a given design concept and LED lighting technology. The design process includes conceptual design, schematics, scaled drawings and study models, construction, experimentation, and assessment of lighting effects within the context of 3-D design. With changes and improvements in LED technology, students explore first-hand its properties, advantages, and limitations, while building upon a foundation of illumination knowledge. Students are thus able to evaluate 3-D form and techniques within a functional design context as well as formulate valid assessment criteria of design solutions.

In the first semester, students focus on how to utilize professional modeling materials to enhance the atmosphere of a space through design and lighting. Experimentation through sketching and study models affords students the opportunity to explore different techniques with various materials, as well as allowing students to capitalize on the different qualities of LED lighting. Students work with an actual campus space and have the opportunity to test their results on classmates and fellow students alike. Special attention is paid to construction detailing and model quality for the duration of the project in the first semester, with an emphasis on professional and appropriate modeling materials. Additionally, students are evaluated on the proper quality of light produced for the space and the incorporation of a design theme.

Students follow the initial semester experience with their completed luminaires in the second course when lighting effects and technology advancements are explored. With continuous changes in LED technology for architectural lighting, students are able to experience the rapid advancement in this field with an updated palette of lamp selection in the second semester. As printed course materials do not necessarily keep pace with current LED products, this course experience enables students to analyze and evaluate advancements in the technology. By studying the interaction of light with form, texture, and materials, students are able to assess the impact of their design on the interior environment.

Introduction

Teaching methods in interior lighting courses become increasingly challenging to keep up with technology as advancements are continuously put into production for consumers. The current lighting textbook used in the course addressed in this paper published its newest edition a year ago to include LED technology. While it is a significant update to the previous edition, it is outdated already in the latest LED technology; it does not address the qualities of light distribution that LED lamp manufacturers are designing into the latest products. For example, the newest omni-directional lamps such as the Osram Sylvania product shown in Figure 1 is appropriate as a traditional A-lamp retrofit by distributing light in a similar 360° pattern and

providing dimming capability. Earlier A-lamp replacement models such as the example in Figure 2 distribute light from the upper portion of the bulb and are not dimmable.



Figure 1 – Omni-directional LED lamp¹



Figure 2 – LED A-lamp replacement¹

Other qualities continuously developed in LED A-lamp and other bulb shapes are improved color rendering and a wide variety of color temperatures. These are perhaps the most crucial characteristics for students to observe and learn as they lead to positive consumer response and acceptance. Without observing differences for example, between a 3000°K and a 3500°K LED lamp, students will not understand the critical similarities between traditional incandescent technology and current LED products for consumer acceptance. This is a particularly important quality in the U.S. and other countries that have regulated production of several common standard incandescent lamp types for energy improvement initiatives. In the U.S. for example, as a result of the Energy Independence and Security Act of 2007, 100-, 75-, 60-, and 40-watt standard incandescent lamps have been removed from production to be replaced by their more energy efficient LED, halogen, or compact fluorescent counterparts². It is critical for students to learn developments and advancements in lighting technology such as these to have the latest and most appropriate tools available for their lighting design solutions.

Literature Review

There is minimal literature available on pedagogical methods of lighting education in the last several decades with fewer recent examples. Brent³ studied teaching lighting technology in a comprehensive manner to sophomore/junior-level students in a commercial design context. It was hypothesized that all students would perceive and construct lighting design solutions different from one another. Similar to the project addressed in this paper, Brent's study required

students to focus on the programming design phase so that their individual solutions were based on similar input. This paper's project however, diverged by allowing students to create their own lighting product using the most current lamp technology, whereas Brent's project utilized existing lighting products. Brent's project did not include hands-on experimentation and experience evaluation of lamp and fixture light quality and distribution effects.

The International Association of Lighting Designers (IALD) conducts an annual interactive exploration of light for students at its LightPlay program for student awardees. Two students from IUPUI have participated in this program in the past and ideas from the program's experiences inspired the study of light and form in the project addressed in this paper. For example, in 2009 "students used filters, flashlights and fruit in various locations to discover and document how light moves, reacts and shapes an environment"⁴ as seen below in Figure 3.



Figure 3 – IALD Student Experiences at LightPlay⁴

Students selected to participate in LightPlay experience first-hand how light interacts with form while experimenting with various light sources and props that affect their distribution. In this way, students learn not just about the technical aspects of lighting but they learn how to predict lighting results in application.

Recent literature suggests a need for emphasis on sustainable design practices including energy efficiency. Stieg⁵ proposes that pedagogical methods in these areas, including energy efficient lighting, should be given particular emphasis toward professional practice even if it is necessary to lessen emphasis on design practices in other areas. She suggests that as the built environment

becomes more complex and continuing education does not fill the “sustainability gap” there is a need for specialization in particular building practices such as these. As advances in LED technology surge and indications are that it is becoming a primary sustainable building solution, there is little written about teaching students how to understand and incorporate these new advances.

Lighting Assignment Overview

In the fall semester of 2013, 12 students enrolled in a sophomore level three-dimensional interior design studio were given the assignment to both design and build a light fixture using LED technology for the common areas in the basement of a campus building. Various experiences are housed within the common areas including: booth seating for 6 to 8 students, individual study tables, a print station, various couches and lounge seating and small tables accommodating two students per table.

Parameters for the project included: utilizing a maximum of three medium-base light sockets with an attached cord, designing and building with professional modeling materials in mind, and designing for how each light fixture would be attached to the existing structure. Special attention was paid to the quality of light, appropriate use of construction materials, and the craftsmanship of the model and drawings. Additionally, reflectivity, translucency and transparency were to be considered. Students were permitted to use the following modeling materials: foam core, museum board, chip board, bass wood, balsa wood, and vellum. If any additional materials were desired to be used, prior instructor approval was required, and materials were approved on a case by case basis based on material appropriateness and material workability. Overall, if a student wished to use a material other than what was listed above, the professor encouraged the student to use traditional modeling materials, and to be creative with how to mimic the material they wished to use.

At the beginning of the project, the class collectively decided on a theme. Though each student would be independently designing her own fixture, the class had to determine an overall style, or theme, for the common areas. After a group brainstorming session, the class decided to design all light fixtures with the concept of “global industrial”. The theme was chosen because of the existing design influences already present in the common area spaces. With exposed structure and systems on the ceiling above, and display cases exhibiting technological advancements around the world, the students felt that continuing with a worldwide industrial theme was most appropriate.

Conceptual Design – Part I

After the theme was decided, students were allotted one week to design three distinctly different concept models to smaller scale for their chosen space. Upon completion of the various schematic designs, the students tested their fixtures in their assigned spaces and were given feedback from the instructor about successes and opportunities for improvements. Additionally, the students spoke very openly with one another about suggestions and lessons learned with their own projects. Student comments included different tips on how to work with certain model materials, as well as, tricks on how to make a certain material behave a certain way. The

collective learning that happened in these informal critiques was very beneficial to the entire class. This project invoked a sense of camaraderie instead of competition, as students worked individually to appropriately convey a concept collectively. Below are samples of students' schematic design light fixtures, and their corresponding inspiration.



Figure 4 – Study model with an inspiration from an industrial oil rig



Figure 5 – Study model with an inspiration from historic window patterns



Figure 6 – Study model inspiration from clock roman numerals

Conceptual Design – Part II

Next, the students were to choose two of their schematic design concepts to develop and build at full scale. The students were given one week to build full scale study models for each of their chosen spaces within the common areas. The students once again received instructor and student feedback about construction quality, lighting quality, materials selections, as well as advice about next steps. After this second interim critique, students were to move forward with one final design, and were given two weeks to complete a full scale, presentation quality model, and a complete set of construction drawings. Student progress is shown below with evidence of their two, more refined preliminary models shown in their prescribed locations.



Figure 7: Student displays light fixture over circular seating area. Her inspiration was from global, industrial architecture.



Figure 8: Student displays light fixture at the print station. Her inspiration was from sound waves.



Figure 9: Student displays inspiration from an industrial fan



Figure 10: Student displays inspiration from a diving mask

Final Designs

On the project due date, students hung their completed light fixtures and drawings in their designated areas as shown in Figures 11, 12, and 13 below. Then, as a class, the students walked around to examine and admire their classmates' projects. Additionally, much attention was received from other building occupants who were intrigued and inspired by the light fixtures installed at various places. After walking around the common areas, students then spent ten minutes presenting their final light fixture designs to the class. Students discussed their successes and struggles with different modeling materials, various LED lamps and construction techniques. The students were required to save all of their drawings and models for use in their upcoming class that focuses on the principles of lighting technology.



Figure 11: Final student light fixtures. Concepts from left to right: industrial fan, metal cages, technological waves.



Figure 12: Final student light fixtures. Inspiration from left to right: kerosene lantern, clock, furnace system.



Figure 13: Final student light fixtures. Student inspiration from left to right: gears, conveying systems, oil towers, diving mask.

Student Feedback

The students who completed this project were very satisfied with the final product. Upon project completion, the author requested feedback about the successes and weaknesses of the project. Below is a sampling of the student responses.

Student 1: “Initially, I was displeased when the professor required me to complete a second set of study models. At the time of the assignment, it seemed redundant and like a waste of time. However, upon completion of the second study models, it was clear to me that this allowed me to work out any final kinks in my design and construction, and allowed me to create a much more polished final product.”

Student 2: “This project helped me to understand how light shines through different materials, or how it doesn't at all. I also learned, for this project specifically, we need to think about the whole picture of where the light is going to be installed, what it looks like at the bottom and inside since it's being installed above our heads, what it looks like when light shines through, is it maybe too bright or too dim, lastly how our light fixture will be erected and held in place. These are all things that after our final projects were done we all sort of scrambled to figure out and didn't really think about this with our process very much.”

Student 3: “The biggest success of this project was that we were able to create our own concept as a class and see it through from start to finish. We decided on the concept *Global Industrial* and it was neat to see everyone's interpretation of it. Even though we all had the same concept, each person had a design that was so unique and different. This project was a great learning experience because we had the opportunity to create something that could be applied to in real life. One thing I really enjoyed was that we got to set the fixtures up in the basement and see how it would look in a real life setting. I would highly recommend this project for future classes!”

Project Development

The project is intended to last multiple semesters with the greatest number of students involved in these projects set to 18 at the maximum. Students typically work individually but, in the beginning, may work as a class, or in small teams. Students start with the design and construction of their light fixtures in the studio class, and then will continue their learning in a lighting class in a future semester. Assessment of the success of these projects is typically retrieved from end of semester student evaluations. As we continue to develop the project we intend to create specific assessment tools for each project.

The second phase of this project is the successive course that students are required to complete at the junior level, “Environmental Lighting Design”. In this course, students will bridge their lighting education by building upon their initial experience designing and constructing their LED luminaire. While the initial experience emphasizes the form of light and experiential effects of the LED source, the secondary experience will emphasize technical aspects of the LED source and particular distribution patterns based on specific LED lamps.

In the secondary phase of the project, students will be required to purchase an LED lamp of

their choice with a medium-base socket. In their study of LED technology, they will learn about the Lighting Facts initiative that required a label of all LED lamp products as of March, 2012. Students learn how to read, interpret, and apply the label information for commercial and residential lighting projects. An example of the label is shown in Figure 14.

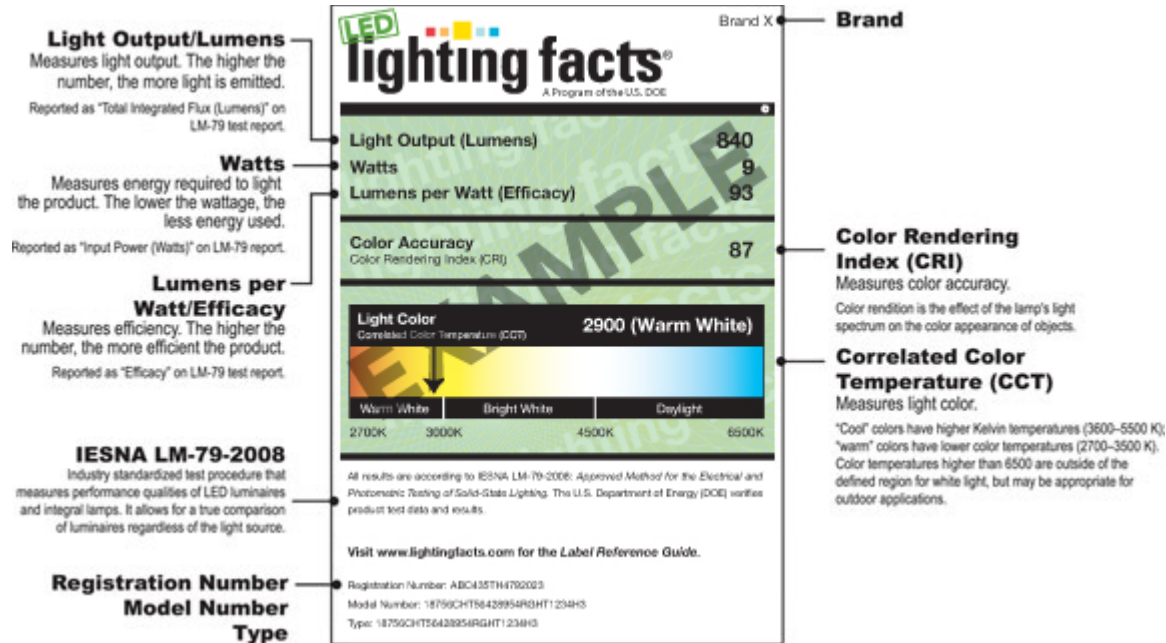


Figure 14 – Lighting Facts Label⁶

With a project maximum enrollment of 18, students in the Environmental Lighting Design course, will experience the effects of a variety of lamps in their constructed luminaire from the previous course. A study of the lamp characteristics as outlined in the Lighting Facts label will be compared for differences in color appearance, color rendering, and light output. Additionally, light distribution patterns and potential dimming capabilities will be experienced and compared between lamp examples.

Through this methodology, students will gain a first-hand understanding of the technology underlying currently available lamp products. This will enable them to specify lamp solutions in their design scenarios later in the course and eventually, in design practice. It will encourage them to design environmentally friendly, sustainable design solutions as suggested by Stieg⁵.

To evaluate student understanding of lighting technology and solutions, several assessment methods will be employed. Students will begin the course with a pre-course survey to assess their understanding of LED technology and product types. The same survey will be administered at the conclusion of the course to compare student understanding from the beginning of this experiential method. In addition, formal assessment will occur through examination at the conclusion of the event. The goal is to reveal successful understanding of LED technology so that students are prepared to carry forth their knowledge and application into professional design practice.

Summary and Recommendations for the Future

In moving forward with this project, the students from the fall 2013 semester have been required to save their light fixture projects for future semesters. While there were many successes of this project in the fall 2013 semester, the authors believe the largest success was the students' opportunity to see a project through the entire design process. Often in the educational world, students create concepts and preliminary designs, but are not afforded the opportunity to see the project through to completion. This project allowed students to experience the intricacies and frustrations entailed when actually constructing a project. Furthermore, constructing the light fixture at full scale allowed students to grapple with detailing, joinery and construction quality, all of which are hard to grasp at the schematic design phase.

Another success included the investigation of different LED light sources. IUPUI purchased 12 different styles, types, wattages, and color temperatures for experimentation for this project. Students quickly learned about lighting quality, power, and temperature through the trial and error of sampling different LED lamps in their full scale study models. The ability for students to physically touch and experience the ambiance and light created from the actual lamps was an invaluable experience for the entire class.

While the first phase of the project was an overwhelming success, there are a few minor things the authors would change in coming semesters. Most of the classroom experience was spent on the physical modeling of the light fixture. Students were also required to complete construction drawings of their fixtures, though not much attention and time was devoted on this portion of the project. Moreover, it was evidenced by student work that each student either focused the majority of her time and energy on the physical model or the on the construction drawings, but not both. Due to the relatively short timeline for this project, approximately four weeks from start to finish, the author would recommend either increasing the length of time dedicated to this project, or decrease the amount of product required from the students.

Additionally, while most students excelled at developing their concept from one critique to the next, the professor struggled to assist all students adequately in evolving their designs from the previous rendition. In the future, the authors would suggest providing an assessment rubric to further encourage students to develop their fixtures each step of the way.

The second semester of the project in the "Environmental Lighting Design" course will provide assessment of the secondary experience with the underlying initial work as a basis. As the project enters its second and successive implementation with each additional cohort of students, evaluation results will be compared to further refine educational practice and to incorporate continual advancements in LED technology.

1 Osram Sylvania. (n.d.). *Lamp and ballast e-catalog*. Retrieved from <http://ecom.sylvania.com/sylvaniab2b/b2b/catalogstart.do?search=catalog>

- 2 U.S. Department of Energy. (2012). *New lighting standards begin in 2012*. Retrieved from <http://energy.gov/energysaver/articles/new-lighting-standards-begin-2012>
- 3 Stumpe, R. (1985). Instruction in Lighting Design. *Journal of Interior Design*, 11: 18–22. doi: 10.1111/j.1939-1668.1985.tb00044.x
- 4 International Association of Lighting Designers. (2009). *More than 35 students attend Enlighten Americas 2009*. Retrieved from <http://www.iald.org/about/events/EnlightenAmericas2009.asp>
- 5 Stieg, C. (2006). The Sustainability Gap. *Journal of Interior Design*, 32: vii–xxi. doi: 10.1111/j.1939-1668.2006.tb00252.x
- 6 Lighting Facts. (2013). *Anatomy of the label*. Retrieved from <http://lightingfacts.com/Library/Content/Label>