Lighting education online:
development of an interactive, Internet-based education program in lighting

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ABSTRACT

There are a number of professionals involved in the evaluation, selection, specification, installation, and maintenance of lighting systems who have little or no formal education or training in the lighting field. Surveys have indicated that approximately 75% of the lighting designed and installed in the United States is done without the consultation of an experienced lighting professional[1]. Many decisions about lighting installations are made by electrical contractors or other professionals within the building trades. These "non-lighting" professionals responsible for this sizable portion of lighting installations are often apprehensive about using new, more efficient technologies or systems because of a lack of understanding of how these systems operate. Building professionals, such as electrical contractors, also often have difficulty in accessing courses or seminars sponsored by universities or professional associations, and often cannot afford the cost or time of these programs. The authors set out to develop a lighting education program that would meet the education needs of non-lighting specialists, that would be easily accessible, affordable, flexible, and applicable to the needs of practicing building professionals.

With funding from the New York State Energy Research and Development Authority (NYSERDA), the Lighting Research Center (LRC) of Rensselaer Polytechnic Institute undertook a project to identify the lighting information needs of a variety of groups within the building professions that would be likely to select, install, or maintain lighting systems. A systematic survey of these professionals was completed via email and postal mail to determine their current knowledge level of lighting technologies and systems, typical lighting-related tasks they performed, and their preferred methods of receiving education. Based on the results of these surveys, the LRC determined that an Internet-based program would be the most effective method of reaching these professionals.

The authors subsequently designed and developed a comprehensive system of professional development in lighting that would allow working professionals to take individual courses in lighting at their own pace and level of understanding. Curriculum was written based on the needs assessment conducted as well as an understanding of current best practice in lighting. This curriculum was then developed into a unique interactive, Internet-based education program entitled *Lighting Education Online*, accessible anytime, anywhere, from the desktops of the learners.

INTRODUCTION

Lighting systems being installed in many new and renovated buildings in the United States still use outdated, and inefficient lighting equipment despite the wealth of information about new, more efficient lighting technologies. The authors felt that a major reason for this was simply a lack of understanding of how newer technologies operate and how best to incorporate these technologies into a

1. United States Department of Energy, 2000. Vision 2020: Lighting Technology Roadmap, US DOE, Washington D.C.

building project. Simply put, a busy building professional is going to select equipment with which they are most familiar, that is easy to install, and that has operated well for them in the past – an "I will not use what I do not understand" mentality.

The LRC approached NYSERDA for funding for the development of an education program for lighting specifiers in New York State under the premise that many of the people making decisions about the lighting to be installed either in new construction or building renovations within the State were unfamiliar with how to select and use newer, more efficient lighting technologies. Therefore, if a concerted effort were made to educate these lighting decision makers about newer technologies, this would make them more likely to select these technologies in the future. It is a key component of NYSERDA's mission to improve the efficiency of buildings in New York State. This fits well with the mission of the LRC to advance the effective use of light. Because the proposed education program fulfilled the mission and priorities of both entities, project funding was awarded and the project began.

NEEDS ASSESSMENT OF LIGHTING DECISION MAKERS

The first step in the project was to conduct a needs assessment of a broad cross section of professionals that the LRC identified as being involved in the lighting decision making process in New York State. Lists of professionals working within New York State were obtained from professional, trade, and industry associations. Surveys were distributed via postal and electronic mail to all of the professionals for whom contact information was available. Approximately 1000 surveys were distributed and 120 completed surveys were returned, yielding a 12% response rate. The distribution of the completed surveys among the various professional groups was roughly equivalent to percentage distributed to each group so the LRC felt that responses were broadly representative. Respondents were asked to select the job category that most closely resembled the majority of their professional practice. The percentage of respondents representing each job classification were as follows:

- Architects 18%
- Engineers 20%
- Building construction contractors 8%
- Electrical contractors 10%
- Interior designers 4%
- Electric utility representatives 2%
- Energy service company personnel 4%
- Lighting sales representatives or distributors 21%
- Government personnel 11%
- Respondents not identifying their profession 2%

Next, respondents were asked to identify the lighting-related topics about which they felt they most needed education. A list of nine possible topics was provided and the most frequently selected were:

1. Selecting lighting controls that save energy and perform well
2. Energy efficient lighting technologies
3. How to design lighting that is visually appealing
4. How to determine how much light is needed for a particular application
5. How lighting effects people's health, well-being, and productivity.

Respondents were then asked to identify their interest in receiving education about specifying lighting from a list of eight application types. The three applications most frequently selected were:

1. Health care settings
2. Educational facilities
3. Offices.

Respondents were asked to select the means through which they would most like to receive education. The three top selections were:

1. Over the Internet 36%
2. At regional seminars 23%
3. In written materials 22%

Finally, respondents were asked if they used computers as part of their professional practice and were also asked about their computer and Internet capabilities. Responses were as follows:

- 96% of respondents used a computer as part of their professional practice
- 90% of respondents used an IBM compatible personal computer
- 96% of these computers had a CD-Rom drive
- 93% of respondents used email regularly
- 95% of respondents had access to the Internet.

Based on these survey responses, the LRC made the following determinations:

1. Building professionals and related lighting decision makers identify that they have a difficult time selecting energy-efficient lighting products.
2. Lighting decision makers most want education on lighting controls and other energy-efficient lighting technologies, followed by education on lighting applications and lighting design considerations.
3. The lighting applications that lighting decision makers in New York State were most concerned about were health care settings, educational facilities, and offices.
4. The largest percentage of lighting decision makers would prefer to receive education via the Internet followed closely by local seminars and written materials. These reposes seemed to indicate a strong preference not to have to travel to receive education (the selection "at national con-

ferences" was selected by less then 5% of those responding).

5. Most building professionals and lighting decision makers regularly use computers as part of their professional practice and have access to the Internet.

CURRICULUM DEVELOPMENT

The LRC developed a team of lighting researchers, educators, and curriculum developers who were charged with developing an education program that met the priorities identified in the needs assessment. It was first determined that the education program would be delivered via Internet. This determination was made for several reasons:

1. The professionals surveyed indicated a preference for this delivery mechanism and the capacity to receive education and information in this manner.

2. The widest possible number of participants could be reached in a cost-effective manner via an Internet-delivered program versus locally provided seminars.

3. Recent research on professional education has shown that education provided via an Internet-based program can lead to better long-term retention of the information provided[2].

4. An Internet-based program would provide a good deal of flexibility in updating and changing content as lighting technology and practices improved, and this would also allow the LRC to add additional content as needs were identified.

Because of the unique delivery mechanism selected for the educational program, an experienced Internet content developer was added to the team to assist with program design and development of the program structure. It was an important priority that the structure of the educational program allow for the maximum flexibility both for developers and, ultimately, for users. Therefore, it was decided early on the courses would be developed using a "modular" format of short self-contained courses that could be easily reconfigured as needed. This format also lent itself to Internet-delivery because it would allow users to take the courses in small intervals or lessons that would have a "seat time" of less then one hour per session. The program was named *Lighting Education Online* because developers felt this best conveyed the essence of the program's content and delivery mechanism.

One of the priorities of the curriculum development team was that *Lighting Education Online* allow for totally asynchronous learning. In other words, a person taking a course should be able to take each lesson at anytime, from anywhere without having to follow a predetermined schedule. It was felt that one of the shortfalls of many university sponsored Internet-based education programs was that they required students to adhere to the rigid semester and class structure of traditional campus-based programs. In most university Internet classes students must register and begin classes at a set time (i.e., at the beginning of a semester or term) and students must complete content within a structured period with weekly assignments and so on. Working professional have a very difficult time is adhering to these traditional class schedules because they often have little control over their own projects. Therefore they need an educational program that they can complete as their time and schedule permits. It was also important to developers that all course content could be completed on line without the need to download assignments and submit them separately. This meant that even the testing or quiz components of the program needed to be completed on line.

The process used to developed curriculum for *Lighting Education Online* followed typical educational course development principles and processes. Once the team prioritized the program operating parameters, curriculum developers set about deciding how many courses could be developed within the set time period and budget. Based on the feedback received during the needs assessment phase of the project, the team decided to create four distinct courses that would become the basis of the *Lighting Education Online program*. The initial courses decided upon were:

- Lighting Terminology
- Lighting Technology
- Lighting Applications
- Lighting Design.

Once course topics were determined, the curriculum development team set educational goals for each course, determined what topics would be covered in the courses, and then set objectives for each course lesson and topic. Because *Lighting Education Online* was being designed as a continuing professional education program, it was important to developers that the content of each course have immediate practical application to the potential users. Therefore, each course goal and objective was very "practically" defined. For example, the goal of the *Lighting Technology* course stated

"*Learners will know the operating characteristics of commonly used lighting technologies, be able to critically assess lighting products, and select technologies and systems that will best meet the needs of particular applications.*"

One team member was assigned as main author for each course and he or she worked with various content experts at the LRC to develop the content based on the defined objectives. The Internet content development expert worked closely with each course author throughout the writing process to assure that such issues such as course length, content interactivity, and graphical compatibility were taken into account as content was developed. Authors were asked to include ideas for graphics, illustrations, and "animated" content in their written document to help guide the Internet content developers in their work. Once each section or lesson within a course was developed, it was

2. Masie, E., 2001. E-Learning: If we Build it, Will They Come, ASTD/The Masie Center, Alexandria, V.A.

passed onto the Internet content developers on the team to begin their work of developing the graphic and interactive content. Authors reviewed these as they were being developed to assure that they met the educational needs of each lesson.

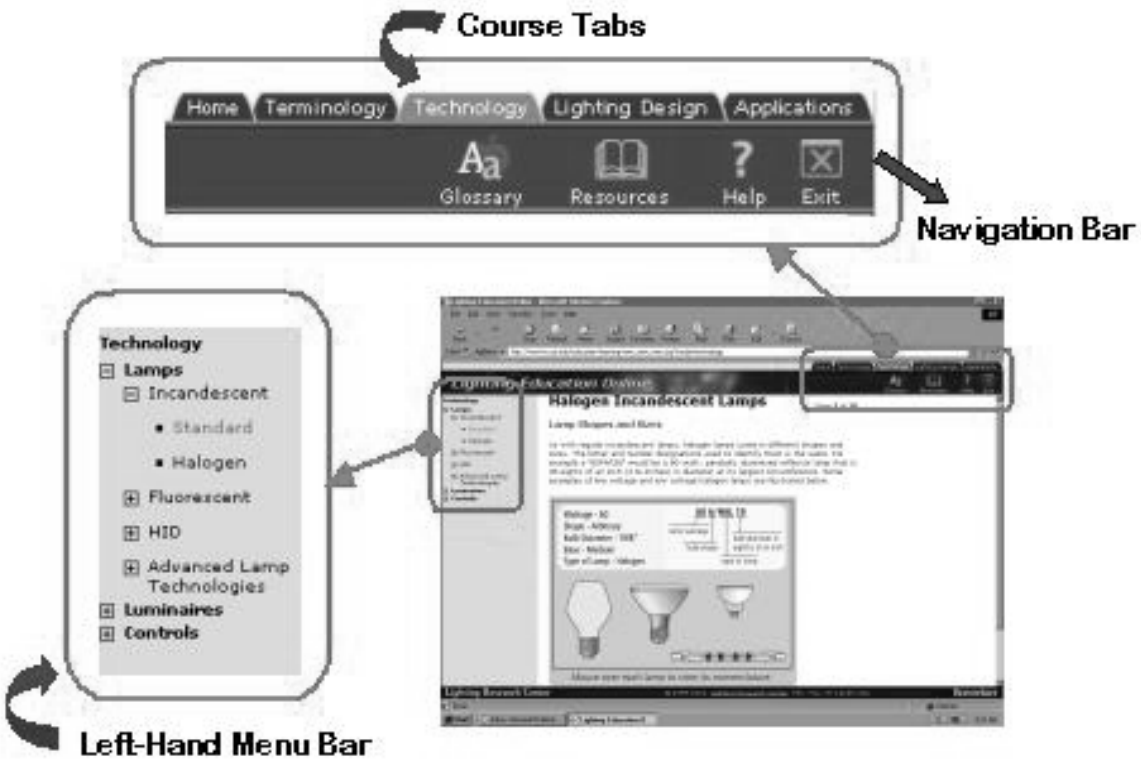
An important consideration in the curriculum development for *Lighting Education Online* was the idea of interactivity and content reinforcement. In an "in-person" class or seminar, the instructor uses a variety of mechanisms and techniques to provide information to class participants. These same techniques are important to online learning environments. A course instructor (in this case the online course) must first introduce a topic or concept, teach the basic knowledge required to understand the concept, apply the concept or knowledge to practice, and review or reinforce the concept before going onto the next topic. *Lighting Education Online* typically introduces each topic with text supported by illustrations. The "teaching" or knowledge acquisition section of each topic again uses text and illustration but typically adds an animation as an interactive element to help keep the user engaged in lesson. The application of this knowledge to practice is again accomplished through an interactive element in the program that requires a learner to "do" something with the knowledge they have acquired. Finally the content is reinforced and a short quiz is included at the end of each topic. Interactivity between the user and the program is considered key to the online learning process. No more than two pages of *Lighting Education Online* pass without a section of animated content that requires a user to interact with the program. This keeps users engaged in the content, and generally prevents them from "skimming" through the content on each page.

Another important feature of *Lighting Education Online* is its ability to track a students' progress through the course. This is done though the use of multiple-choice quizzes at the end of each topic level of the program. The quizzes fulfill three basic functions. First, they allow each learner to gauge their own understanding of the content. If a learner does not answer each quiz question correctly, they are encouraged to review the topic they have just completed and must take the quiz again. Secondly, the quiz acts to reinforce important concepts in the lesson. Each quiz question is designed to repeat the most important concepts so that a learner is forced to review these concepts for a second time. Finally, the quizzes allow the LRC some level of assurance that a user has understood the course content and should be awarded credit for completing that section.

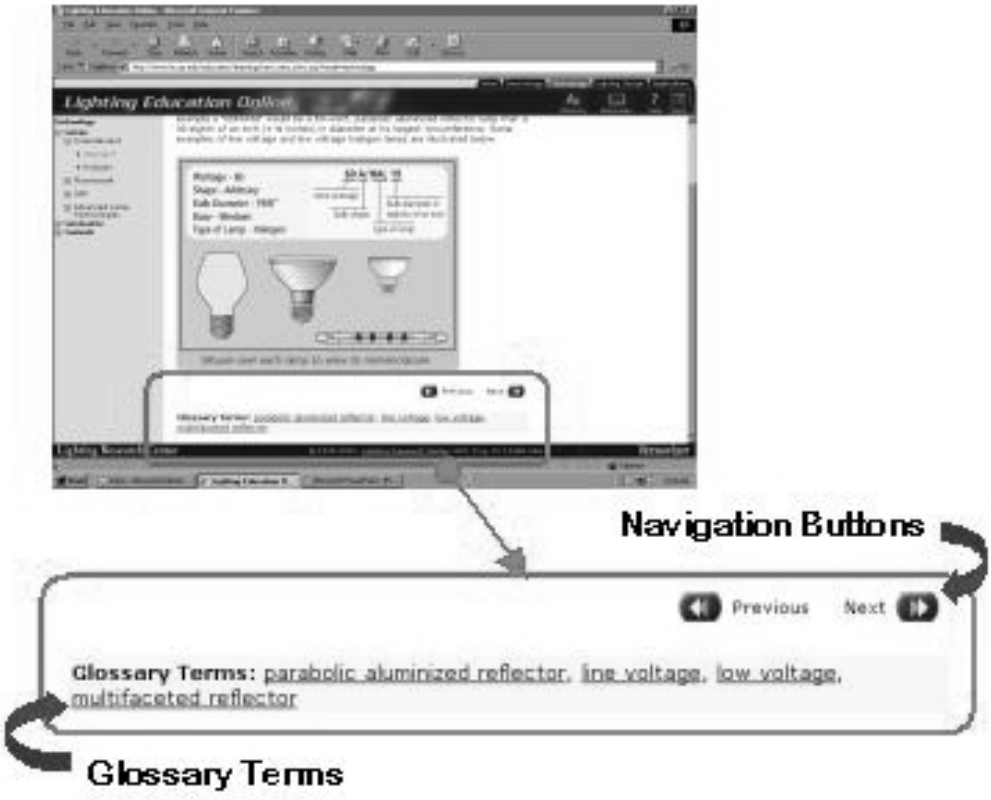
INTERNET SITE DESIGN

As curriculum authors were developing course content, Internet communications specialists were developing the structure that would convey the content to the learners. The *Lighting Education Online* Internet site is designed for easy navigation and use by people taking the courses. There is a consistent navigation bar across the top of each page with "tabs" that allow a user to select the course they would like to review. This navigation bar also allows users continuous access to the program's glossary, the program resources page which contains links to lighting manufac-

Course Navigation and Menu Features



Individual Page Navigation Features



tures and information on other resources that a user may want to access for more information on a topic, a help button that allows the user to email a question on course content directly to the LRC, and a button to exit the program. On each page there is also a left-hand menu bar that displays the various lessons and topics within each course. This allows users to easily move around within each lesson, review previous sections, and move ahead to the next topic. An illustration of these page features is shown below:

At the bottom of each page there are also consistent navigation buttons for users to move forward or backward within a lesson. In addition, a list of glossary terms used on each particular page is also included at the bottom of the page with quick links to the glossary to review the meaning of the term, if needed. These page features are illustrated in the graphic below:

PROGRAM STRUCTURE

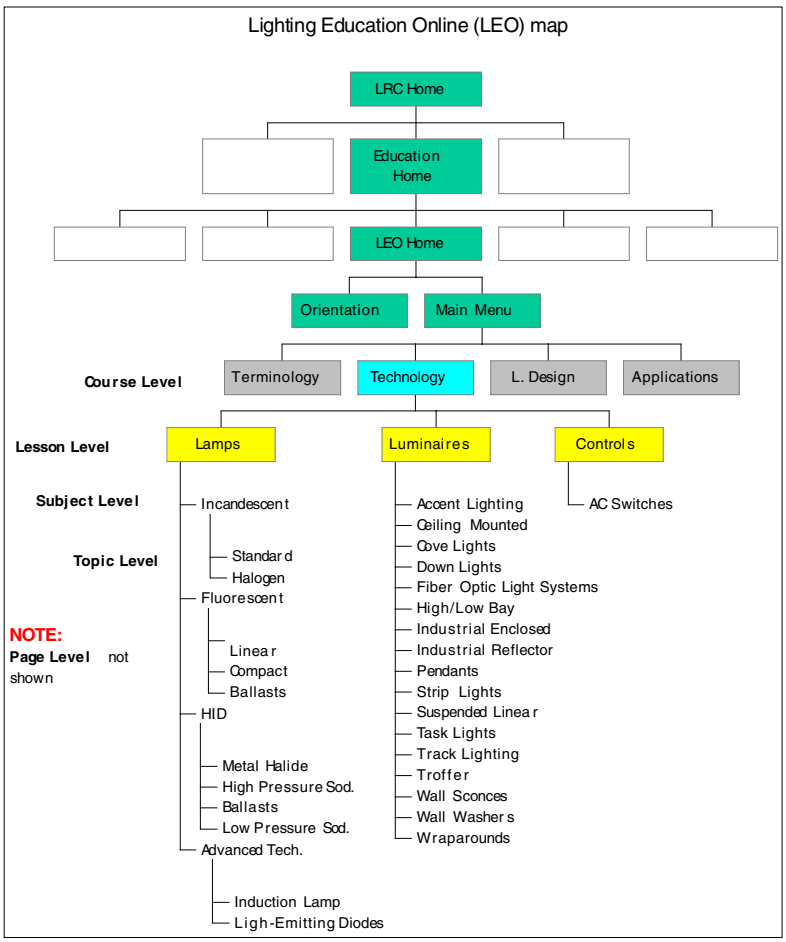
Lighting Education Online is made up of individual courses, each covering an important area of lighting practice. Each course within the program follows a consistent structure so that users quickly become accustomed to navigating through the courses. In a typical curriculum outline format, the course structure appears as follows:

I. Course *(i.e., Lighting Technology)*
A. Lesson *(i.e., Lamps)*
a. Subject (*i.e., Incandescent Lamps*)
1. Topic (*i.e., Standard Incandescent Lamps*)
i. Page (i.*e., Introduction to Standard Incandescent Lamps*)

As you see in the *Lighting Education Online* program map below, all participants enter the program through a *Lighting Education Online* homepage directly from the homepage of the Lighting Research Center. This page provides a brief introduction to the *Lighting Education Online* program, and gives the participant options to review an orientation, or move to the main course menu to select a course. The main menu lists each of courses with brief outlines of their content. Once participants select a course, they are directed to a registration page through which contact and professional information is collected. It is also at this point that the course fee is paid via credit card (participants also have the option of sending payment by check). Courses are reasonably priced based upon the number of credits awarded, and participants can download a password and begin immediately upon entering their payment information.

A partial program outline showing some of the individual lessons within the *Lighting Technology course* is shown below. This illustrates the modular structure of the courses: (see figure next page).

Each of the four courses was similarly mapped out so that curriculum writers and content developers would



have an idea of the individual components that would be needed.

At the beginning of each course there is an introduction that explains the structure and content of the course. Following this introduction participants move to the course menu, which divides the course further into lessons. In the illustration above the **course**, *Lighting Technology* is divided into three **lessons**, *Lamps, Luminaires,* and *Controls*. Participants are directed to complete the lessons in the order listed. Once a participant selects a lesson, they then move to the subject level. Again using the illustration above, the **lesson**, *Lamps,* is divided into four **subjects**, *Incandescent, Fluorescent, HID, and Advanced Lamp Technologies.* The final level that participants access is the topic level. This divides each subject into the topics that will be covered within it. In the figure above, for example, **the subject**, *Incandescent Lamps*, is divided into two **topics**, *Standard* and *Halogen lamps*. Each of these topics contains the course content in a similar format and ranges from five to ten pages depending on the complexity of the information provided.

COURSE CONTENT

Once the curriculum development team determined what the content of each course would be, each individual course author selected the logical structure for the content within each course and the level of detail that would be provided. The driver behind the course content was that it should only include information necessary to professionals involved in the practice of lighting. This necessitated a very "practical" approach to the educational content, with limited theory and detail that might not be applicable to the work of a typical building professional. It was also decided that some content would need to be omitted both because it would not be widely relevant to most potential course participants and also because of time and space constraints within the program itself. For example, within the lesson on lamps no information was provided on neon, cold-cathode, or other primarily decorative or specialty type lamps because it was determined that most "non-lighting" professionals rarely specified these types of light sources in general practice. The structure and content of the current *Lighting Education Online* courses is described below.

Lighting Terminology

Although the program has a glossary that defines all of the technical terms used in the courses, it was decided that there would need to be a course that would provide a student with a more in-depth understanding of certain key terms used extensively in lighting practice. The curriculum development team narrowed these key terms down to fourteen that were considered essential knowledge, that were most frequently used in the courses, and that were

most often misunderstood by general building professionals. These terms are:

- Ballast
- Ballast Factor
- Candela
- Candlepower Distribution
- Correlated Color Temperature
- Color Rendering Index
- Efficacy (of a light source)
- Efficiency (of a luminaire)
- Glare
- Illuminance
- Lamp
- Life (average rated for a light source)
- Light
- Lumen
- Luminaire
- Luminance
- Reflectance
- Spectral Power Distribution

Each lesson in the *Lighting Terminology* course begins with the "official" Illuminating Engineering Society of North America (IESNA) definition of the term or concept. This is followed by a further explanation of the term in simpler language typically using a number of examples. Finally the use of the term or concept is applied to practice using illustrations or interactive animations. Participants in *Lighting Education Online* are expected to complete the *Lighting Terminology* course first, before continuing on to other courses. In addition, the first time any of the fourteen lighting terms (above) is used in any other course, each term is "linked" back its lesson in the Lighting *Terminology* course.

Lighting Technology

The *Lighting Technology* course is subdivided into three lessons that cover the basic technologies used as part of lighting systems – lamps, luminaires, and lighting controls. Topics within each of these lessons follow a consistent format providing information on each individual technology. For example, for each topic or subtype within each lamp family, the program reviews

1. Typical applications for the lamp type
2. Lamp operation
3. Available shapes and sizes of the particular lamp
4. Lamp nomenclature
5. Information on lamp correlated color temperature(s), and color rendering abilities
6. Lamp life
7. Lamp light output and distribution
8. Lamp efficacy
9. Electrical operation
10. Cost (initial and life)
11. Safety and disposal issues

Each of the above topics is taught on its own Internet page and all of the individual topics or lessons end with a five question multiple choice quiz. Participants taking the course must answer all five questions correctly before moving on to the next topic. The sections on luminaires and lighting controls follow similar formats, with each lesson having a consistent structure throughout.

Lighting Applications

The lighting applications lessons are currently in development and will cover three application types, healthcare facilities, educational facilities, and offices. As with the lessons in the *Lighting Technology* course, each of the three lessons in the application course follows a consistent, defined format and provides the following information and design guidance for each application:

- An introduction discussing the various "room" types within each application
- Lighting design and lighting quality considerations for each room type
- Human factor considerations, for example
  a. Glare
  b. Luminance of room surfaces
  c. Illuminance (vertical and horizontal)
- Architectural integration and visual appeal, for example
  a. Appearance of the space and luminaires
  b. Light distribution
  c. Color appearance
- Energy efficiency, for example
  a. Energy codes and regulations
  b. Control strategies for saving energy
  c. Design strategies for saving energy
- Costs, for example
  a. Initial costs
  b. Long term operating costs
  c. Maintenance costs
  d. Life cycle costing

Each of the topics shown above varies for each application depending on the issues that are considered to be most important in the particular application type. Each lesson will also include examples illustrating current "best-practice" for lighting in each application. Once again, each of the individual topic areas above ends with a quiz that participants must pass before moving on to the next topic. As with all of the courses in *Lighting Education Online* each lesson and topic contains interactive animations that engage the learners as they progress through the lesson.

Lighting Design

The *Lighting Design Course* will be the next in development and will include information on

1. The lighting design process
2. Human factor considerations in lighting design
3. Lighting evaluation
4. Lighting economics
5. Design documentation
6. Installation and commissioning issues

CONCLUSIONS AND LESSON LEARNED

Lighting Education Online has enjoyed great interest and excellent reviews in its first few months of operation. Currently, two courses, *Lighting Terminology* and *Lighting Technology*, are accessible to the public. Over twenty building design and installation professionals have accessed these courses within the first two months. Plans are underway to add new courses at regular internals over the next two years, which will build the program into a comprehensive system of professional development in lighting for building professionals. Feedback from users has been very positive. Users particularly like the interactive content and sophisticated graphics. The program structure is working well and users are able to easily navigate through each course. The help feature that allows learners to email questions to experts at the LRC is functioning well and the LRC has been able to respond to each question within twenty-four hours. Learners have done well completing the course quizzes with most participants being able to answer all questions correctly. There has been one participant thus far who successfully completed both of the first two courses. The LRC is tracking each participant's progress through the program, including the time that it takes each learner to complete each lesson within a course, and hopes to have additional data available on users within the next few months. The LRC also plans to conduct a more formal survey of users once a critical mass of learners has completed the courses. The LRC expects between 200-300 learners will access courses in *Lighting Education Online* each year.

Although recent electronic course developers have been apprehensive about providing lighting education courses over the Internet because of the limitations they felt this would place on the use of high-quality graphics and animations[3], the LRC has found that no users have had difficulty easily "downloading" and using any of the course content even from a typical phone modem connection. The LRC also did extensive testing of the program using a variety of Internet-connection speeds and capabilities and found no difficulty in accesses or downloading course content. Another issue identified by previous developers of electronic courses was the cost of Internet-access for learners[4]. In the United States, this is not typically an issue because most professionals have unrestricted access to the Internet usually for a small monthly fee.

The development of *Lighting Education Online* has been an exciting and sometimes frustrating learning experience for the authors. The challenges of developing educational content for delivery on the Internet have been many and varied. Because of the wide variety of professionals that need to be involved in the process, (i.e., content experts, curriculum developers, and Internet communication specialists) project coordination has been particularly difficult and time consuming. It is very important that clear, well-defined roles and responsibilities be established before beginning this type of project. It is also important that each team member be aware of what other curriculum writers and developers are doing and understand their capabilities and limitations. It is also key that everyone involved understand the schedule and time needed for each step in the process. This is particularly important for the development of graphical and interactive content for the Internet, which can be a very labor intensive and time-consuming process.

Lighting Education Online is accessible through the LRC's website at www.lrc.rpi.edu

3. David, J., 2001. A New Approach to Lighting Education in the UK, Proceedings of Lux Europa 2001 the 9th European Lighting Conference, pp. 152-157.
4. Ibid.