The effect of active learning in an interior design daylighting module

Geethapriya Balasubramanian
Iowa State University

Follow this and additional works at: https://lib.dr.iastate.edu/rtd

Part of the Architecture Commons, Art Education Commons, Graphic Design Commons, Higher Education Commons, and the History of Art, Architecture, and Archaeology Commons

Recommended Citation

This Thesis is brought to you for free and open access by the Iowa State University Capstones, Theses and Dissertations at Iowa State University Digital Repository. It has been accepted for inclusion in Retrospective Theses and Dissertations by an authorized administrator of Iowa State University Digital Repository. For more information, please contact digirep@iastate.edu.
The effect of active learning in an interior design daylighting module

by

Geethapriya Balasubramanian

A thesis submitted to the graduate faculty
in partial fulfillment of the requirements for the degree of

MASTER OF FINE ARTS

Major: Interior Design

Program of Study Committee:
Dorothy L. Fowles, Major Professor
Frederic C. Malven
David A. Block

Iowa State University
Ames, Iowa

2006

Copyright © Geethapriya Balasubramanian, 2006. All rights reserved.
TABLE OF CONTENTS

LIST OF TABLES vi
LIST OF FIGURES vii
ACKNOWLEDGEMENTS ix
ABSTRACT x
THESIS SEQUENCE xii

CHAPTER 1: INTRODUCTION 1

Statement of the Problem 1

Building industry and energy concerns 2
Design education and research 5
Interior Design program and daylighting 8
Educational options 8

Scope 9

Purpose 10

CHAPTER 2: LITERATURE REVIEW 12

Overview 12

Interior Design Directions 12

Sustainable Design Developments 14

Daylighting 15

Importance of daylighting 15
Critical information on daylighting concepts 17

Undergraduate Education Directions 18

Classroom research 20
Learning and teaching 22
Research on teaching 22
Paradigms of student learning 25
Active learning strategies 29
Issues about active learning 32
Research questions 35
Objectives 36
Summary 36

CHAPTER 3: RESEARCH METHODOLOGY 37
Overview 37
Statement of Hypothesis 38
Research Setting 40
Research participants 40
Courses involved in the research 41
Research components and sequence 42
Description of research data components 45
Interior Design Analysis exercise (IDA) 45
Interior DayLighting quiz (IDL) 47
Design Project (DP) 49
Student Reflection write-up (SR) 51
Daylighting instructional module 52
Content 53
Criteria for intervention design 54
Testing Procedure 55
Pilot testing 55
Human subjects approval 56
Interior Design Analysis pre-intervention exercise (IDA) 56
Interior DayLighting pre-intervention quiz (IDL) 57
Instructional interventions: Lecture and Active Learning (X1-L and X2-AL) 57
Interior DayLighting post-intervention quiz (IDL) 59
Interior Design Analysis post-intervention exercise (IDA) 59
Design Project (DP) 59
Student Reflection write-up (SR) 60
Research tests evaluation 60
Data analysis 61

CHAPTER 4: RESULTS 63

Overview 63
Measurement instruments 63

- Measurement 1: IDL – Interior DayLighting quiz 64
- Measurement 2: IDA – Interior Design Analysis exercise 77
- Measurement 3: DP – Design Project review 80
- Measurement 4: SR – Student Reflection write-up 89

CHAPTER 5: DISCUSSION AND CONCLUSION 92

Overview 92
Statement of hypothesis 93

- CR 1: Student knowledge, comprehension, and application of daylighting information 94
- CR 2: Student analysis, synthesis, and evaluation of daylighting information 96
- CR 3: Student use of daylighting information in the appropriate context 97
- CR 4: Student impression on the learning process 99
**LIST OF TABLES**

**Table 1.** Research component evaluation summary: Evaluators and method of evaluation  
61

**Table 2.** Mean scores for IDL pre-test convergent & divergent thinking questions and p-value for difference between the two groups  
66

**Table 3.** Mean scores for each group for each IDL pre-test questions and p-value for difference between the two groups  
67

**Table 4.** Mean scores for IDL post-test convergent & divergent thinking questions and p-value for difference between the two groups  
69

**Table 5.** Mean scores for each group for each IDL post-test questions and p-value for difference between the two groups  
70

**Table 6.** Gain scores for IDL overall test, convergent & divergent thinking category questions and p-value for difference between the two groups  
75

**Table 7.** Gain scores for each group for each IDL post-test questions and p-value for difference between the two groups  
76

**Table 8.** Cronbach’s Alpha - Inter-rater reliability test  
78

**Table 9.** Mean scores for each group for daylight count and theory integration in IDA pre-test and p-value for difference between the two groups  
78

**Table 10.** Gain scores for each group for daylight count and theory integration in IDA post-test and p-value for difference between the two groups  
80

**Table 11.** Mean scores for each group for student daylight count, researcher daylight count and theory integration in DP and p-value for difference between the two groups  
82

**Table 12.** Text analysis of student reflection write-up  
90
LIST OF FIGURES

Figure 1. Three areas of interest in research. 10
Figure 2. Research design: Pre-test –post-test comparison group design 44
Figure 3. Frequency distribution of IDL overall pre-test scores:
Lecture group (n=13) and active learning group (n=13) 65
Figure 4. Frequency distribution of IDL overall post-test scores:
Lecture group (n=13) and active learning group (n=13) 68
Figure 5. IDL overall test score: Composite of Q1 to Q6 for pre- and post-test scores for lecture and active learning groups 71
Figure 6. IDL convergent thinking category score: Composite of Q1 to Q3 for pre- and post-test scores for lecture and active learning groups 71
Figure 7. IDL divergent thinking category score: Composite of Q4 to Q6 for pre- and post-test scores for lecture and active learning groups 72
Figure 8. Comparison of pre- and post- test group performance for each IDL questions. 73-74
Figure 9. IDL overall test, convergent (Q1 to Q3) and divergent (Q4 to Q6) gain scores comparison for lecture and active learning groups. 75
Figure 10. Gain scores comparison for each group for each IDL question level 77
Figure 11. Mean scores comparison for each group for daylight count and theory integration in IDA pre- and post-tests 79
Figure 12. Gain scores comparison for each group for daylight count (IDA_DiffCt) and theory integration (IDA_DiffTh) in IDA post-test exercise 80
Figure 13. Design Project: Daylight concept use count by student & number of students 83
Figure 14. Design Project: Daylight concept use count by researcher & number of students 83

Figure 15. Design Project: Daylight theory integration scores & number of students 84

Figure 16. Mean scores Design Project evaluation based on student design teams 85

Figure 17. Mean scores of design teams comparing daylight concept use (DSN_DL_Ct) in Design Project with the divergent thinking IDL post-test score (Aavg4_6) 86

Figure 18. Mean scores of design teams comparing daylight concept use (DSN_DL_R_Ct) in Design Project with the divergent thinking IDL post-test score (Aavg4_6) 87

Figure 19. Mean scores of design teams comparing daylight theory integration (DSN_DL_Th) in Design Project with the divergent thinking IDL post-test score (Aavg4_6) 88
ACKNOWLEDGEMENTS

This research project is a culmination of the support and guidance of many individuals. First, I would like to thank my major professor, Prof. Dorothy Fowles, whose strong passion for academics and the research topic in particular, was a constant booster for my project. She was my true mentor and I admired her able guidance during my thesis project, allowing me to explore but at the same time guiding me when I went astray. This thesis would not have developed into its current form without her constant encouragement and writing directions. Second, I would like to thank my committee members, Dr. Fred Malven for his ideas, suggestions, and participation in the research process and Prof. David Block for his continued support and timely insights on the research topic.

Thanks to Ms. Amy Mickovek and Ms. Pam Iasevoli for their valuable time and help. I would also like to thank Lori, Claudia, Elaine, Lorna, Ryan and Stacy for helping me at various stages of my research project. Also special thanks to the students, my research participants, who willingly took part in my research project. Prof. Mack Shelley and Ms. Man-Yu Yum from the Statistics department, and Prof. Mary Huba in the Department of Educational Leadership and Policy Studies made this research a very good learning experience and proved to be a valuable part of my research process.

Thanks to the Art & Design department & College of Design, my professors, and the design students who have contributed so much to my experience in Iowa State University.

Thanks to god and lastly, thanks to my parents, my sisters and their families who have always given me constant support. Special thanks to my mom, Lakshmi, who is my strongest support and belief system, living half way around the globe.
ABSTRACT

This study is an experimental endeavor involving two instructional interventions for teaching a design concept. The sustainable design concept of 'interior daylighting' is instructed to the third year interior design students as part of the lectures in the 'Interior Materials Systems and Details IV' course. The purpose of the study is to analyze and compare the effectiveness of using active learning strategies with the lecture method of instruction. The effectiveness of the strategies is assessed based on the following three questions coined by Prof. Bonwell along with Bloom’s Cognitive Taxonomy (Bloom et al., 1956):

1. What do I want my students to know?
2. What do I want my students to do?
3. What do I want my students to feel?” (Bonwell, 1996, p. 6).

The thesis research methodology addresses various active learning strategy issues raised by earlier researchers. The students are randomly assigned to the two instructional method groups by using a statistical table of random numbers. The learning assessment is done using pre- and post-intervention methods, which includes Interior Design Analysis (IDA) exercise of an interior space and Interior DayLighting (IDL) Quiz. The course Design Project (DP) review and Student Reflection (SR) writing activity on the instructional methods are also used to assess the students’ learning experience.

Inferential statistical analysis was used to establish causal relationship, if any, between the instructional method and learning effectiveness from the obtained results/assessments. Statistical tests like independent t-tests, inter-rater reliability, and frequency distribution of values were used for the analysis. The statistical and content analysis of data
from the research tests indicated that both the Lecture and Active Learning groups showed some improvement in their overall performance after the instructional intervention.

Though the overall difference in performance between the groups was not very high, the active learning group showed a relatively significant better performance in the higher order questions compared to the lecture group. In conclusion, the active learning instructional module appears to have been effective in creating higher order thinking (at least for the short term) among the students. Though the research failed to establish a significant relationship between instructional method and information transfer across course contexts; it could serve as a suggestion for possible future research to test transfer of information across courses. Even within the course, in the final design projects of the active learning students compared to the lecture students seem to be relatively more effective in integrating the daylight design theories and concepts within their designs. Using qualitative analysis, the research also revealed attitude difference among students and the positive thoughts and reactions to the daylighting instructional intervention by the active learning students. The student reflection on the instruction methods gave insights into the general research procedure and the effectiveness of smaller groups and also the importance of student participation in the learning process.

Finally, the research shows that though certain issues in incorporating active learning in conventional lectures were addressed in this study, more refinements need to be done to improve this model for future research in this subject. For this limited sample, the active learning instructional module showed relative increase in performance than the lecture method of instruction, suggesting its potential for replacing conventional teacher-centered lectures in design non-studio courses.
THESIS SEQUENCE

The thesis has the following five chapter sequence:

Chapter 1 introduces the research, the problem statement, purpose, objectives, research questions and the scope of the thesis.

Chapter 2 gives insight into the literature relevant to the research, including daylighting concepts, active-learning theories, and other related research.

Chapter 3 states the hypothesis and operationalizes it. The research methodology used to find answers for the research questions are detailed including an overview of the research method, research subjects, interventions administered, assessments, as well as evaluation and analysis procedures used in the research.

Chapter 4 summarizes the statistical analysis of the results from the data collected in the research.

Chapter 5 discusses the statistical analysis and its meaning to the research question and hypothesis. It derives conclusions from the analysis and explains the implications and limitations of the research. The research is summarized and future research directions are suggested.

The appendix at the end of the chapters includes the forms & instruments used in the research and are followed by the references.
CHAPTER 1: INTRODUCTION

Statement of the Problem

"Learning is not a spectator sport. Students do not learn much just by sitting in class listening to teachers, memorizing prepackaged assignments, and spitting out answers. They must make what they learn part of themselves" - Chickering & Gamson, 1987 (as cited in Bonwell & Eison, 1991, p. 3).

As noted by Chickering and Gamson, a student’s learning experience is complete and beneficial only when he/she is able to absorb the underlying concepts, relate it to different contexts and eventually apply it where appropriate or needed. They emphasize the need to talk, write, relate and apply what is learnt to get a complete understanding. In order to give students such an educational experience, there is a need to analyze the existing techniques and refine them to suit the high standards of learning outcomes that are envisioned for the students. It becomes even more important to have such a learning experience when the subject under question is crucial to the well being of people and the environment (Sterling, 2004).

In line with the thoughts of Sterling (2004), this thesis focuses on student learning of environmental issues within the context of design education. To establish the importance of and provide a context for the research topic, this chapter gives a brief introduction to the building industry - related environmental issues (daylighting in particular), the role of interior design profession and education in daylight design, and education options in the context of higher education involving higher levels of thinking.
Building industry and energy concerns

Global environmental issues like climate change, population, pollution, persistent demand on natural resources, and energy are gaining center stage in our society (Smith, 2003). Every individual on the face of the earth is in some way or the other part of this global phenomenon. The built environment contributes to a major portion of the energy/resource consumption. According to the Roodman & Lenssen (1995) report, (as cited in World Watch Institute), buildings use 40% of the world’s materials and energy, 17% of the total fresh water flows, 25% of harvested wood, 50% of CFC production, 40% of the total energy flows, 33% of CO₂ emissions and generate 40% of landfill material. As designers in the building industry we need to understand the significant role that we play in this overall environmental impact.

The environmental impact indicated above is a result of the change in the building industry and human perception of nature that shifted from long standing contextual design solutions evolving through several centuries to a more energy intensive design solution in the last century. “Industrialized societies tend to be less in touch with nature’s rules” (p. 5), using instead a paradigm designed to “tame nature” (McDonough & Braungart, 2003). The forces of nature-like orientation, sun, wind movement, humidity, and other environmental features of the project location have not had a significant influence on most of the recent design solutions. The ability to mechanically heat or cool a space at will has encouraged designers to design spaces that may not be appropriate to the place.

In contrast to this trend of non-confirmation with site context and excessive energy usage in building design, the last decade of the 20th century saw several initiatives taken by the design industry, such as the 1987 UN World Commission on Environment and
Development, compilation of the Environmental Resource Guide, the 1992 Rio declaration on Environment and Development, formulation of Hannover principles, the “Greening of the White House”, an increased emphasis on recycling, Cradle to Cradle paradigm, use of renewable energy source, creation of the United States Green Building Council (USGBC) and Leadership in Energy and Environmental Design (LEED) environmental standards, and an overall emphasis on sustainable design principles and education (Cassidy, 2003). Though each of these initiatives needed more revisions and enhancements, they have been evolving over time, which is an encouraging trend towards creating a better environment. There is also a renewed interest in daylighting due to energy crisis, renewable energy sources, sustainability, and concern for the health and wellbeing of people (Steffy, 2002).

Since the 1970s energy crisis, there has been a constant effort to develop more energy efficient lighting systems. The lighting industry has been, and still is, achieving several significant advances in energy efficiency. Such improvements in energy efficient lighting solutions are more beneficial only with their efficient integration with daylight design and other related building systems. An integrated building systems design solution is an important factor in daylight design and cannot be overlooked (Rea, 2000). While daylight plays an important role in the overall energy efficiency and performance of a building, architects, interior designers, and engineers together play a vital role in reaping the benefits of this light in the building design (Robbins, 1986). The important role of architects and interior designers in utilizing daylight in their building designs is noted by Rewi (2006), as follows:

“The beneficial biological effects of daylight on humans are now quite clear”, says Lars Bylund, Ph.D., IEA, Professor of Light and Energy at Norway’s Bergen University School of Architecture and a lighting designer . . . “And if we are talking
about efficient lighting and sustainability, those benefits are very important. Architects and interior designers have a responsibility to utilize daylight more.” (p.40)

While Rewi (2006) identifies both architects and interior designers to have a significant role in utilizing daylight more, interior designers’ role in the integrated design solution for daylighting greatly responds to or compliments the given architectural context. The daylighting principles in a building design are further enhanced by the interior design decisions that are critical to the successful integration of daylighting in the design solution (“Daylighting”, 2002).

David Ejadi, principal of a commercial conservation program, stated that “successful daylighting begins with building orientation and ends with proper daylighting controls ... If interior design is poor, you end up subverting the daylighting system – space planning is important” (“Daylighting”, 2002, p. 162). Thus Mr. Ejadi highlighted the role of architects, building systems engineers and the interior designers in the daylighting process.

Although architects play the initial role in allowing daylight to appropriately penetrate the interior spaces, the interior designers’ decisions become critical in maximizing or eliminating the available daylight, according to Mr. Ejadi. To understand the significant role of interior designers in this process and to achieve an integrated design outcome it is important that valid daylighting design information is delivered to the interior design students. This will enable them to make wise daylight related design decisions within the assigned architectural context.
Design education and research

In view of the importance of daylight in building design and the integrated effort needed to achieve the same, it is also imperative to research and propagate the concept to a wider audience that will have a major influence in the building industry – the design students (Rewi, 2006). Rewi further emphasized the need and importance of daylighting, when he called out for more research on daylighting in schools.

“Ultimately, daylight harvesting will be one of the most important things we do . . . we need people in the process with thoughtful input [italics added]. Thankfully that is happening, but it has to move quickly into the schools so further research can get underway” (Rewi, 2006, p.40).

Research and development in energy efficient building systems is advancing. Students’ understanding of the key concepts of these advancements enables them to become good consumers of research and also eventually conduct research. One of the prime resources that introduce students to such wealth of growing information that includes daylighting and other sustainable design principles is their college education. Students rely on their higher education to develop an understanding of the underlying concepts that form the foundation for future learning experience, resulting in life long learning (Bernauer, 1998).

Contrary to this need for education in sustainable issues, initiatives to integrate sustainable design into the mainstream design education have been slow when compared to the building industry. Interior design programs have been predominantly teaching design principles and theories to create spaces that are emotionally uplifting, practical, and aesthetically pleasing for the users (FIDER, 2002). According to a 2003 online survey
conducted by the design magazine, *Metropolis*, very few schools have sustainable design as part of their design curriculum, revealing the then trend of undergraduate design education in the United States with respect to environmental design/sustainable design/green design (Szenasy, 2003).

A strong development to change this state of affairs in the Interior Design education was the resolution passed at the 2005 Annual International Conference of the Interior Designer’s Educators Council (IDEC), to support the concept of socially responsible design. The resolution stated, “Be it resolved that IDEC supports the concept of socially responsible design including the cradle to cradle paradigm as an integral part of interior design education” (IDEC Annual Report, 2005, p.4). Similarly, in 2006, the Council for Interior Design Accreditation, formerly known as the Foundation for Interior Design Education and Research (FIDER), revised its accreditation standards to emphasize sustainability education in the interior design curriculum (Council for Interior Design Accreditation, 2006).

The current efforts of IDEC and the Council for Interior Design Accreditation in emphasizing sustainable design are complimentary to the responsibilities of the profession of interior design as agreed upon by the, NCIDQ, National Council of Interior Design Qualification (“Who We Are”, 2006). The definition includes a commitment to health, safety and welfare of individuals and also the well being of the community. Beyond being a moral way of approaching design, Mcdonough and Braungart (2002) envision the outcomes of sustainable design concepts as a wise choice. Apart from the environmental benefits, they emphasize the several physical, psychological, social and economic benefits of sustainable design approaches that are appropriate for a wholesome growth of the human race.
As indicated by the efforts of the various interior design organizations, socially responsible design and environmental issues need their due attention and action. It is increasingly important to educate students about the current and future environmental scenario and how to implement positive responses. Students, our future designers, need to understand the significant role that designers play in this sustainable approach to design and how they can contribute positively to the betterment of both our lives and our environment. They need a supportive learning environment to understand and integrate the concepts like energy efficient design into their personal design solutions (Sterling, 2004).

The opportunity to motivate and educate students lies with the educators: it is important to get students thinking about different issues beyond course content in the design field (Centre for Educational Research and Innovation, 2000). Once the students are thinking and questioning different design issues, the job is well begun. This thinking and questioning will eventually motivate them to find answers to their own questions when there are no more teachers to give them the answers. Such a learning experience will hopefully bring in an unstoppable drive in the students to go into a further quest for information (Sterling, 2004).

In other words, motivating students to practice sustainable design concepts like daylighting becomes crucial in design education to make it an inherent aspect of a design solution after graduation. Whatever the reasons might be for traveling the path of environmental design, educators who believe in environmentally responsible design have to expose the students and some times other educators to these concepts (Cullingford, 2004).

Within this context, the importance of a daylight session as an integral part of the Interior Design program at Iowa State University is developed in the following section.
During their four-year program, interior design students at Iowa State University, receive a substantial amount of technical and design information that includes lighting as a semester long course. A two-hour lecture session within this lighting design course covers the topic of daylighting. The class sessions in the course are intended to be helpful in disseminating large amount of technical and aesthetic lighting design information in a short semester period, so that daylighting receives only introductory attention. This thesis attempts to understand and develop a further means for the Interior Design Program at Iowa State University to expose students to daylighting concepts and to conduct research on how to enhance the understanding of daylighting concepts. The main question becomes: “Are students really “learning” the concepts and internalizing them or is it merely an act of delivering information?” It is important for us to understand the role of class sessions and their structure in the overall learning experience and whether any improvements can be made to make them more effective (Bonwell, 1996).

While design studios use a very active learning method of instruction, the lecture format has been used conventionally to impart information to students for use in their design projects. Researchers like Carmean and Haefner (2002), Laurillard (2002) and Buckley (2002) have analyzed the importance of students’ role in the learning process in higher education. The research studies emphasize the need for a paradigm shift in thought process from teaching to learning-centered strategies (Huba & Freed, 2000). Apart from the lecture, which is a more teacher-centered method of instruction, there are other modes of instruction that have more student involvement and may be equally efficient, if not more, than the lecture.
“What is important is for instructors to find approaches that fit their personal style of teaching and meet their educational objectives, while at the same time actively engaging students as they learn in the college classroom” (Bonwell & Sutherland, 1996, p.4). Research on the use of active learning methods in the student learning process in comparison with the conventional lecture helps in understanding the more effective means of student learning. According to Twigg (Shaughnessy & Veronikas, 2004), “we must be aggressive in evaluating learning materials in terms of the impact they have on the students ... we need more of research-based evaluations.” (p.53)

While the common goal in education is effective student learning, how do we define an effective learning experience? Or what constitutes an effective learning experience? Is it the know-how of information or the ability to critically examine the information? Or is it the ability of students to transfer the information to any related context? Or is it the very experience of the students during the learning process that is of prime importance?

Scope

In response to the needs noted above, the general focus of this research is on the effectiveness of undergraduate design education in a non-studio setting. The research is mainly conducted within a specific session on daylighting in an Interior Material Systems and Details IV course in a mid-western design school and hence has its own limitations. The scope of this research thesis is limited to the research context, but the methodology can be easily interpreted for future research in similar classroom environments.

The thesis involves three broad areas of research and addresses a small aspect of each of the three (see Figure 1).
The scope of the thesis within the research context will be more explicit and revealing when the limitations and suggestions for future research are discussed in Chapter 5 after the results of the research is analyzed.

Purpose

The field of undergraduate education is undergoing a major shift to highlighting the importance of learner-centered approaches in contrast with the traditional teacher-centered approaches (Huba & Freed, 2000). Though design education involves much one-on-one interaction both with the instructors and students, the basic means of transferring facts and information is through the “lecture” setting. This study assesses the role of active learning strategy during this information sharing stage and comparing its effectiveness to a conventional lecture format. It is envisioned to be a research model that can be applied to
other similar learning experience investigations, which would eventually reveal the various possibilities and help increase the effectiveness of the instructional methods used in the undergraduate program. One of the questions that are being raised is: Should active learning replace conventional lectures in a design non-studio course curriculum to enhance the learning effectiveness and experience of students?

The purpose of this study has been to investigate the effectiveness of an active, student-centered instruction method compared to a teacher-centered lecture in the context of an emerging issue of social responsibility, sustainable design. Frye (2002) contends that “Colleges and universities are wonderful places. They sustain a culture – one of inquiry and skepticism - that is essential not only to the intellectual life but also to the democratic and economic ideals of the United States.” (p.8). This research is an attempt to understand the effective means of communicating design concepts to the students, especially about subjects like sustainable design that are of prime importance, not only to mankind but also to the larger environment (Sterling, 2004). The insights gained in this research experimental endeavor may pave the way for further refinement of research and also a deeper understanding of the student learning process that would help focus future research.

The literature review in chapter 2 will discuss the three areas of relevant research as indicated in Figure 1, interior design, sustainable design, and undergraduate education, to establish the justification of elements used in the research and the research basis for the thesis.
CHAPTER 2: LITERATURE REVIEW

Overview

This research was developed in an effort to understand the effective means to learn/teach sustainable design concepts in the interior design undergraduate program. The broad context and background for the study relates to issues of interior design field, sustainable design, and undergraduate education. In this chapter, the sustainable design concept of daylighting for interior designers is examined and grouped for use in the instructional session. Additionally, literature on teaching and learning in undergraduate education is reviewed. The theoretical background of the different instructional methods used in the research in the context of undergraduate education: i.e., passive (conventional lecture) and active learning methods of instruction are reviewed. Bloom’s taxonomy of cognitive thinking (Bloom, et al., 1956) is detailed out and related to interior design education. Research questions and objectives are developed from the literature review. The summary at the end of the chapter derives inferences from the literature review that eventually formed the basis for the design and methodology used in the research.

Interior Design Directions

The Council for Interior Design Accreditation, formerly named Foundation for Interior Design Education Research (FIDER) along with other major Interior Design Associations of North America endorses the definition of interior design approved by the National Council for Interior Design Qualification (NCIDQ) in July 2004. To address the changing aspects of the interior design profession, the Council has recently proposed a newer definition and is being reviewed by the various member organizations including the Council for Interior Design Accreditation (“Who We Are”, 2006):
“Interior design includes a scope of services performed by a professional design practitioner, qualified by means of education, experience, and examination, to protect and enhance the life, health, safety and welfare of the public.”

The definition further expands on the services provided and the specific tasks of the interior designer. As per the definition, the interior designer’s role is to improve the quality of life while designing an interior space. Being efficient and protecting the health, safety and welfare of the public are an integral theme of sustainable design principles too (McDonough & Braungart, 2002). In order to test the integration of such sustainable design principles in higher education curricula, *Metropolis* conducted a survey in 2003 addressing design education in North America. The study stated that the result of the survey was not encouraging with “14% of schools in the survey developing programs to educate their teachers and only 25% with a faculty advisor for sustainable design” (Szenasy, 2003, p.104).

Since the 2003 *Metropolis* study, the Council for Interior Design Accreditation redefined the design program standards in 2006 showing a stronger emphasis on sustainable design concepts (Council for Interior Design Accreditation, 2006). The Interior Design Educators Council (IDEC) also joined in the efforts of incorporating sustainable design in the interior design field by passing a resolution to support the cause of ‘socially responsible design’ in its 2005 international annual convention (IDEC Annual Report, 2005, p.4). With these ‘sustainable’ initiatives, the interior design profession has advanced to a great extent towards a stronger commitment to the welfare of the people and the community. The beginnings and the different aspects of sustainability will be discussed in detail in the following section on sustainable design.
The Brundtland Commission that convened in Hannover, Germany in 1992 defined sustainable development as “meeting the needs of the present while not compromising the ability of the future to meet its own needs” (McDonough & Braungart, 2003, p.30). The city of Hannover commissioned ‘The Hannover Principles’ that were intended to be used as a guide by the designers in the 2000 World’s Fair. The Principles, formulated to address the issue of sustainable design, highlights concerns for man’s coexistence with nature, interdependence, spiritual and material consciousness, responsibility to consequences of design, creating objects with long term value, eliminating the concept of waste, relying on natural energy flows, understanding limitations of design and seeking constant improvement by the sharing of knowledge (McDonough & Braungart, 2003). In Cradle to Cradle, McDonough and Braungart (2002), further highlighted the importance of following the lessons of nature and showed the possibility of coexistence of industrial and environmental interests.

To summarize, the need to follow nature’s way and the need to spread that concept summed up the core ideals of the Hannover principles. One of the sustainable design considerations that also enjoyed a special mention in The Hannover principles was the need for human designs to respond to the ‘perpetual solar income’ (McDonough & Braungart, 2003). “Growing evidence of the sustainability paradigm influencing mainstream thinking, policy and practice … - a corresponding response by higher education is both necessary and timely” (Sterling, 2004, p.59). This scenario also applies to the design profession – education and practice. Daylight design that is well integrated within a design process can be a perfect example of a designer’s intent to support and adopt such an evolving sustainability paradigm.
Daylighting

Energy availability and usage has been a constant subject of research since the advent of the industrial era. Human consumption of earth's resources increased with more developments and inventions; and any conflict on development strategies ultimately came down to resource utilization and its availability (Slessor, 2000). One ample source of energy that can be utilized more effectively and one that will stay for many more billions of years is the abundant solar energy.

The sun, its intensity and movement that played a very dominant factor in determining several of man's habitat decisions was replaced with the invention of electric light. The energy crisis of the 1970's revived the use of solar design principles in the building industry and also the connection between building design and energy use (Evans, 1987). Like any other reflex response of a system to a crisis, the building industry also reverted back to electric lighting once the trigger that started it all, the oil crisis, became a thing of the past. To avoid another reversal like that in future, initiative to use solar principles should not be limited to our dependency on artificial sources of energy. When sustainable design concepts evolved in the 1990s, the building design community wished to revive the lost tradition of responding to the sun. Daylighting began again to be recognized as an integral design factor not only for its economic energy benefits but also other human physiological, psychological and performance benefits.

Importance of daylighting. Robbins (1986) listed various reasons to justify daylight as an interior light source including quality of the light, apertures serving for views and as fire exits, energy conservation, opportunity to develop an integrated building system and also a genuine human desire to have natural light. Even when daylight is not exploited for these
benefits, its effect needs to be considered in any space in order to avoid glare and other discomfort issues (Rea, 2000). Human factors (physiology, perception, preferences, and behavior), controlled admission of direct or diffuse daylight, effects of neighboring site features, integration of building systems like electric lighting, fenestration, interior geometry and finishes, manual / automatic control systems and active climate control systems need to be considered for an efficient daylight design.

Familiarity with the science and technology of daylighting will enhance the understanding of how the design of the daylighting concept and the engineering of the daylighting system fit into the building design process. An understanding of this daylighting science is important not only for lighting or electrical engineers but also for architects, interior architects, interior designers, lighting designers, landscape architects, and urban planners (Robbins, 1986). David Ejadi, principal of a commercial conservation program, states the importance of various stages in daylight design. While addressing interior design, he emphasizes, “if interior design is poor, you end up subverting the daylighting system – space planning is important” (“Daylighting”, 2002). While building orientation, site features and overall building design play the initial role in bringing daylight into a space what happens to it within the space is predominantly determined by the interior designer’s decisions. Thus, to realize and integrate the benefits of daylighting and also to eliminate some related performance issues, interior designers play a significant role in the building design scheme.

Robbins (1986) insists that the students of design and engineering also need to learn how to use daylighting as a design element and its implications for other aspects of building design and analysis. Hence, daylight, as a critical design factor, needs to be
integrated in the undergraduate curriculum and students need to learn not only how to gain the benefits of daylighting from an energy standpoint, but also how to efficiently ward off unwanted glare and reflection issues in interior spaces.

Critical information on daylighting concepts. Robbins (1986) in his discussion on daylighting issues emphasizes the need to understand some key design issues before daylighting can be fully utilized as a building environment system (p.11-12).

1. "Need for daylight and sunlight availability database

2. Need for a systematic method of describing daylighting concepts in order to develop design intuition to use daylighting concepts

3. Need for comprehensive methods for analysis of system performance including illumination, energy and visual comfort

4. Need for a method of integrating daylighting and electrical lighting

5. Need for a better understanding of who has the responsibility of designing the daylighting system"

Robbins (1986) explained that the designers have to understand the need for daylighting design and also the variable nature of daylight that depends on location, orientation, reflectivity of materials, just to name a few. To incorporate daylighting into a building design, some design goals need to be set for the use of daylighting (Evans, 1987): obtain daylight in useful quantities; distribute daylight uniformly avoiding too much of dark spots; avoid direct sunlight into the building interior that might cause discomfort due to high brightness contrast ratio or visual discomfort due to glare; and provide controls for electric light to help reduce or eliminate its use when not needed. The IESNA Lighting Handbook (Rea, 2000) has a chapter on daylighting that gives a quick overview of the various topics on
daylighting ranging from definitions to calculation of daylight in a space. Based on the different issues indicated in Rea (2000), Evans (1987) and Robbins (1986) the following critical topics of daylighting may be addressed in a composite daylighting session:

- About daylight: Definition, characteristics and benefits
- Availability of daylight: location and season
- Daylight distribution and interiors
- Daylight integration with other building systems: Electrical lighting
- Daylight performance issues: Glare, brightness contrast, veiling reflection, heat gain
- Examples of application of daylighting concepts and their analysis

This thesis attempted to analyze an effective way of communicating these critical issues on the sustainable design concept of daylighting to the undergraduate interior design students. Sterling (2004) tabulated the paradigm shifts needed for the integration of sustainability within higher education including learning through discovery, learner-centered approach, collaborative learning, linking theory and experience, focus on self-regulative learning with real issues orientation, cognitive, affective, skills related objectives, learning with and from outsiders and higher-level cognitive thinking. So, an understanding of the effective means of teaching the critical topics on daylight design in the undergraduate design classroom is needed.

Undergraduate Education Directions

Higher education has entered a paradigm shift – “from the traditional Instructional paradigm, emphasizing the delivery of content as the principal product of education, to the Learning paradigm, stressing the need to ensure that the content is being delivered within powerful learning opportunities” (Buckley, 2002, p.30). Buckley also listed four critical
approaches to achieve the learning paradigm: Learning centered community and technology, transformational faculty development, institutional change, and course-management systems.

In the March 1987 issue of American Association for Higher Education (AAHE) Bulletin (as cited in Chickering and Gamson, 1999, p.76), Seven Principles for Good Practice in Undergraduate Education were listed: “encourages student-faculty contact, encourages cooperation among students, encourages active learning, gives prompt feedback, emphasizes time on task, communicates high expectations, respects diverse talents and ways of learning.” These principles can be categorized under Buckley’s (2002) first critical approach to learning paradigm - ‘Learning centered community and technology’.

The Education Commission of the States, incorporated these seven principles in a report in 1995, Making Quality Count in Undergraduate Education, and identified attributes that defined a quality undergraduate education (as cited in Chickering and Gamson, 1999, p.78):

“An organizational structure: with high expectations, respect for diverse talent and learning styles, emphasis on early years of study

A quality curriculum : that requires coherence in learning, synthesis of experiences, ongoing practice of learned skills, integration of education and experience

A quality instruction : that incorporates active learning, assessment and prompt feedback, collaboration, adequate time on task and out of class contact with faculty. “
Researches conducted by Slavin (1995) indicate that the application of such attributes needs to be tested for its effectiveness. This thesis was one such attempt in incorporating some of these attributes in an undergraduate course instruction, the attribute of ‘quality instruction’ in particular, which emphasizes student involvement in the learning process and collaboration among students and also with the faculty. Such a learner-centered instruction may be a good means of teaching sustainable design in higher education (Sterling, 2004). This raises issues about classroom research which is discussed in the following section.

**Classroom research**

Classroom research plays a vital role in enhancing the learning experience of students in a course (Cross & Steadman, 1996). Cross & Steadman (1996) defined classroom research as an ongoing and cumulative intellectual inquiry by classroom teachers into the nature of teaching and learning in their own classrooms. It involved several factors like the teachers, learners, and the question that need to be analyzed for better teaching-learning experience and also the lessons learnt for future improvement and application. The behavior and response of students to the class activities, the questions that are raised and the very way in which the class is conducted are all good subjects for analysis and discovery of class dynamics. This raised the need to understand classroom dynamics, expectations and student learning theories.

Classroom research considers the insights to be as important as the findings. The student learning is analyzed by the classroom researchers more through the reasoning ‘why’ (E.g. why did the students perform the way they did in the test?) behind the outcomes of the research instead of ‘what’ or ‘how many’ questions (Cross & Steadman, 1996). Classroom
research encourages any type of research method to know the unknown and to analyze the status quo in their classes. Even if the research doesn’t give the desired results, it is an opportunity to examine the results and thus during the process helps gain valid insights.

Classroom assessment is also a part of classroom research. It addresses the “what” questions of a classroom (Cross & Steadman, 1996). Eg: What did the students learn? The authors categorized classroom assessment based on what was done with the results:

- **Assessment-for-accountability**: is directed to individuals who determine the official rewards and do not have a direct influence on the course.

- **Assessment-for-improvement**: is directed to the teachers who can make a difference in the conduct of the course in future based on the assessment.

The same concept can be applied in a smaller scale for conducting an instructional session. Assessments and feedback during lecture sessions could be seen as assessment-for-improvement where students and the instructors are the beneficiaries. Apart from testing the students at the end with a final exam, a continuous feedback helps both the students and the instructor in the learning process (Huba & Freed, 2000).

Bonwell and Eison (1991) discuss the role of educational researchers and indicated that more than the how-to articles on generating newer ideas, a scientific foundation with emphirical support is needed for future practice. Valuable insight into student learning can be gained, with a proper research procedure and statistical analysis, which could then be used to further modify or develop the model for better teaching/learning performance in the future (Slavin, 1995). With a realization of the classroom researchers to integrate their
efforts with educational researchers (Cross & Steadman, 1996), researches backed with statistical evidence will further strengthen the understanding of the teaching and learning process.

**Learning and teaching**

The two cornerstones that inform our educational practice are research on learning and motivation and research on teaching itself (Svinicki, 1999). Both teaching and learning are inter-related and the effectiveness of one can not be discussed without considering the other. An understanding of the research trends in both learning and teaching will help understand and formulate the future trends in education.

**Research on teaching**

Teaching is a complex, multi dimensional and dynamic activity (Theall, 1999). Factors beyond the teacher's control like student ability, prior preparation, value systems and personal considerations can greatly affect the instructional outcomes. In a 1984 report, Marsh and Hocevar noted that some of the dimensions of teaching listed were: amount learned or value of the course, enthusiasm, organization, group interaction, individual rapport, breadth of coverage, examinations, assignments, and level of work or difficulty. A 1989 study by Feldman (as cited in Theall, 1999) indicated that teachers need not be an expert in each of the above mentioned dimensions to be effective. According to Theall (1999), it is safe to say that attention to the teaching dimensions will likely result in a more effective instruction, and ignoring them risks reducing the effectiveness.

Bloom's taxonomy of the cognitive domain, developed in 1956, has had a significant impact in the education system of America (Bonwell & Sutherland, 1996, p.6). A committee
of colleges, led by Benjamin Bloom, identified three domains of educational activities in *Taxonomy of Educational Objectives: The Classification of Educational Goals* (Bloom, et al., 1956): Cognitive: mental skills (*Knowledge*); Affective: growth in feelings or emotional areas (*Attitude*); Psychomotor: manual or physical skills (*Skills*). An analysis of Bloom’s taxonomy proves a guide to understand and develop an effective teaching/learning experience.

Bloom’s Taxonomy was simplified by Prof. Bonwell, who came forth with the following three questions: "(1) What do I want my students to know (2) What do I want my students to feel and (3) What do I want my students to do?" (Bonwell C.C., 1996, p.6).

To address such educational objectives, the type of questions and the style of questioning in a classroom could set the tone of the course and also affect the students’ expectations and participation in the ensuing discussion (Myers, 1988, Spring). According to Myers the role of a tutor is to question, to listen and to help only after asking the students to help themselves. Ellner and Barnes indicated that the effective techniques of questioning include careful planning of key questions that give direction to the lesson plan, logical sequencing of clear questions and encouraging participation from more students, giving them sufficient time to think and respond (as cited in Bonwell & Bison, 1991). According to Bonwell and Eison (1991), the goals of student participation, information retention, application, motivation, and higher order thinking can be achieved by careful planning, thoughtful implementation and a supportive classroom environment. The instructor’s ability to involve students in the discussion also played an important role in the effective student learning process. The first three levels (knowledge, comprehension, and application) describe convergent thinking process which involves recall of information, comprehension and its eventual application. The next three levels (analysis, synthesis, and evaluation) describe divergent thinking process, where processing of information is with new insights.
(Sousa, 1995, p.118). Educational institutions have adopted Bloom’s list of cognitive thinking levels in their active learning efforts in the classroom.

McTighe in the Maryland State Department of Education used the cognitive taxonomy to design a guide for question types (as cited in Bonwell & Eison, 1991, p.25) and the following is a brief list and explanation given for the six levels of cognitive thinking.

- **Knowledge**: Identification and recall of information
- **Comprehension**: Organization and selection of facts and ideas
- **Application**: Use of facts, rules and principles
- **Analysis**: Separation of a whole into component parts
- **Synthesis**: Combination of ideas to form a new whole
- **Evaluation**: Development of opinions, judgments or decisions

Project Lea/RN (1998) at Iowa State University, summarized a list of sentence and question skeletons in 1998 in ‘active learning in college classrooms’ workshop manual:

- **Knowledge**: What does ____ stand for? ; What is ____?
- **Comprehension**: Name two instances where ____ occur? ; What is the difference between ____ and ____?
- **Application**: Use your knowledge of ____ to ____ ; Using ____, build ____.
- **Analysis**: Which steps are important in the process of ____? ; What is the relationship between ____ and ____?
- **Synthesis**: Make a hypothesis about ____; Change ____ so that it will ____.
- **Evaluation**: What solution do you favor and why? ; Rate the relative value of these ideas to ____.”
While Bloom’s cognitive taxonomy is a good resource to structure the instruction questioning strategies to test student learning in the daylighting module, some of the wider research agenda suggested by Bonwell and Eison (1991, p. 78) are:

- Modifying the lecture – Subtle changes that can be easily incorporated
- Alternatives to lectures involving active learning – Quantitative evidence
- Focus on more variables – Long term impact of instructional techniques
- Faculty assuming greater role in educational research
- Publishing the results of research

Paradigms of student learning

Student learning can be broadly categorized into two groups or paradigms – the traditional teacher-centered learning and the student-centered learning (Huba & Freed, 2000): The teacher-centered paradigm involves knowledge transmission from teacher to students who passively receive information. Assessments are used to monitor learning with an emphasis on right answer and the learning culture is competitive and individualistic. These features are contrasted by the learner-centered paradigm that actively involves students in constructing knowledge. The learner-centered method emphasizes generating on better questions, learning from errors and assessments are used to diagnose and promote learning. The learning culture is cooperative, collaborative and supportive, wherein both the teacher and students learn.

Teacher-centered paradigm of student learning — Lecture. Herr (1991) noted that the lecture is the most commonly used instructional method for the large class and will remain so. Appropriate uses of lecture are to collect, organize and report materials on a topic, to demonstrate enthusiasm for the subject and sharing personal experiences related
to the subject, to explain complex concepts and ideas introduced in the reading, and to suggest appropriate contexts for such concepts (Cooper & Robinson, 2000). Lecture preparation is also a useful tool for teachers to reflect on the course content.

With its own inherent advantages, the lecture mode of instruction has been the conventional way of teaching large classes. The lecture mode of instruction has always been credited with being able to cover more information compared to an active mode of instruction which relatively takes more time. Lectures are also criticized for covering too much information by the active learning supporters who stress the importance of covering subjects more in-depth instead of rushing through the topics. Herr (1991) stresses the importance of not trying to cover everything about a subject, because it is better to teach less, but teach it effectively. The lecture was indicated to be least preferred when the information is already available in print (Cooper & Robinson, 2000).

**Learner-centered paradigm of student learning – Active learning.** Lectures are more effective when used along with other teaching strategies. Students will remember more if brief activities are introduced to the lecture (Prince, 2004). Several research studies that incorporated active learning strategies in their instruction showed significant positive effects on student learning and perception including research by Laws et al (as cited in Prince, 2004), Paulson (as cited in Faust & Paulson, 1998).

Though introducing activities within a course increases student performance, Bonwell (1996, Fall) listed several logistical issues involved in lecture enhancement such as physical limitations of the room, class size, choice of strategies and students’ knowledge of the subject. The author also concluded that the key to the success of lecture enhancement
efforts was to think carefully about what needs to be accomplished, to reflect on the context of the classroom, and then to plan structured activities.

There are many ancient quotes on learning and teaching concepts including one that is very appropriate to understanding active learning (as cited in Silberman, 1996, p.1):

“What I hear, I forget
What I see, I remember
What I do, I understand”

- Confucius (2400 years ago)

In his book, *Active Learning: 101 Strategies to Teach Any Subject*, Silberman (1996, p.1) further elaborated & enhanced the crux of Confucius’ thought:

“What I hear, I forget
What I hear and see, I remember a little
What I hear, see, and ask questions about or discuss with someone else, I begin to understand.
What I hear, see, discuss, and do, I acquire knowledge and skill
What I teach to another, I master.”

The term “active learning” is used and interpreted in several ways within the education field. As the term suggests, the instruction method or the learning experience is “active” in nature. It can be either physical or cognitive action that keeps the students and the teachers engaged with both becoming active participants in the learning process. The term ‘participants’ is very crucial in describing active learning because both the students and the teachers ‘participate’, hence learning from the experience. Both are ‘active’ and the
explicit intent of active learning methods is to improve the learning of students. But the teachers also learn and refine their strategies in the process as there is a constant feedback and reflection from the students. A working definition for active learning in a college classroom is proposed as a learning method that “involves students in doing things and thinking about the things they are doing” (Bonwell and Eison, 1991, p. 2). They also identified one of the important gaps in higher education as the one between ‘how faculty typically teach’ and ‘how they know they should teach’ (p. 4).

Bonwell and Eison (1991) listed some general characteristics associated with active learning strategies in a classroom: students are involved in more than listening; less emphasis is placed on transmitting information and more on developing students’ skills; students are involved in higher-order thinking (analysis, synthesis, evaluation); students are engaged in activities (e.g., reading, discussing, writing, etc.); greater emphasis is placed on students’ exploration of their own attitudes and values. Similarly, in 2002, Carmean and Haefner developed a core set of ‘Deeper Learning Principles’ – an engaged learning that results in a meaningful understanding of material and content. The Deeper Learning Principles include learning that is social, active, contextual, engaging and student-owned. Along with these principles there is also a need to emphasize the importance of long-term memory and learning based on building enduring conceptual structures (Foreman, 2003).

The one underlying emphasis that can sum up these views on learning is that the real understanding of concepts can be revealed in the ability of the learner to apply those concepts in different situations. It is not just factual information recall, but a more applied use of the gained factual knowledge that can be credited to an effective learning experience.
Active learning strategies:

Students are simply more likely to internalize, understand and remember material learned through active engagement in the learning process (Bonwell & Sutherland, 1996). There are several strategies of teaching and learning within such an active learning model of instruction ranging from group learning to individual activity. Not every active learning method suites all circumstances. The choice of an activity depends on the instructor’s preferences, course objectives, and the nature of the subject. Having emphasized the need for student active learning and its aptness for learning sustainable design concepts (Sterling, 2004), a deeper understanding of the active learning strategies – development and research – is essential. These deeper learning concepts of active learning that are social in nature and student-owned (Foreman, 2003) are reviewed in the ensuing pages for their inherent characteristics and advantages.

The core elements of Active Learning are student activity and engagement in the learning process. Some common forms of Active Learning beyond small individual student exercises are collaborative, cooperative and problem based learning (Prince, 2004).

- **Collaborative learning** refers to any instructional method in which students work as teams towards a common goal. Student interaction and team achievement are the main ideals of this method.

- **Cooperative learning** is also a team method of instruction in which students work as teams towards a common goal but also give importance to individual assessment. Learning is through cooperation and not competition.

- **Problem-based learning** (PBL) can either be a team or individual instructional method. Problems are introduced and the learning process, which can be mostly self-directed, continues till the completion of the project.
“When using groups within a class for active learning, the use of group goals or group rewards enhances the achievement outcomes of learning, if and only if, the group rewards are based on the individual learning of all group members (Slavin, 1995).”

The cooperative learning method with a single goal for a team concept does not perform well compared to group learning environments that have individual accountability built-in to the team achievement. Webb indicated that giving or receiving answers without explanation generally reduces achievement (as cited in Slavin, 1995). In other words, each student must be able to individually explain the stance of their group thus emphasizing individual understanding of the topic of discussion. This eliminates the downside of group work with just one member dominating the group discussion.

Out of the 64 studies in cooperative learning that gave group rewards based on individual performance, fifty (78%) found significantly positive results and none had negative results. The median effect sizes of studies with such a reward approach was 0.32 compared to a 0.07 of studies with only one or no group goal or product. This research finding (as cited in Slavin, 1995) emphasizes the need for both group and individual goals to achieve learning effectiveness.

The active learning strategy of cooperative learning applied to design classrooms translates perfectly to the real world design practice where designers always work as a team. Similar to the group active learning strategies explained above, the design discipline including daylighting design is a collective effort of various design professionals (Robbins, 1986) each within their individual design realm but working towards a common goal. With its emphasis on group goal and individual accountability, cooperative learning strategy with
student teams may work as a good means of teaching daylight design in an undergraduate interior design course. The following section on cooperative learning cites some cooperative learning strategies and research findings to support the same.

**Cooperative learning.** The criteria for an effective learning experience of the students have been widely researched. A meta-analysis of 375 research studies looking at how successful competitive, individualistic and cooperative efforts are in promoting productivity and achievement (Johnson, Johnson & Smith, 1991) concluded that cooperative learning promotes higher achievements than does competitive or individualistic learning (effect sizes = 0.67 and 0.64 respectively)

Carefully planned cooperative learning involves people working in teams to accomplish a common goal, under conditions that involve positive interdependence and both individual and group accountability (Smith & MacGregor, 1996). Cooperative learning or peer learning groups introduced in a conventional lecture method of instruction will transform it into an active learning experience for the students.

In 1998, the Learning Enhancement Action/Resource Network (Project LEA/RN™, 1998) at Iowa State University compiled a list of active learning strategies with individual accountability that could be implemented in college classrooms including Jigsaw, Turn To Your Partner (TTYP), Read and Explain Pairs (REP) and Note Taking Pairs (NTP).

- **Jigsaw:** Group effort in studying and sharing information about sections of a topic
- **TTYP:** Consulting partner after developing an individual stance
- **REP:** Reading and explaining chapters to partner and relating to previous sections
- **NTP:** Comparing and sharing notes with partner and discussing key points
Institutions have integrated active learning strategies similar to these in their instruction. In a study by Ruhl et al (as cited in Prince, 2004), involving 72 students over two courses in each of two semesters, the researchers analyzed the effect of interrupting a 45 minute lecture with three 2-minute breaks in which students clarified their notes in pairs (NTP strategy). It was termed as the ‘pause procedure’. In a short-term recall exercise, students under the ‘pause procedure’ could remember 108 correct facts compared to the straight lecture group with 80 correct facts. The ‘pause procedure’ group with scores of 89.4 and 80.4 in a long-term retention multiple choice test for the two classes outperformed the lecture group that had scores of 80.9 and 72.6 respectively. These results indicate the positive impact of introducing a simple active learning strategy to enhance the learning effectiveness.

Issues about active learning

Benjamin Franklin stated: (as cited in Bonwell and Eison, 1991, p. 80)

To get the bad customs of a country changed and new ones, though better, introduced, it is necessary to first remove the prejudices of the people, enlighten their ignorance, and convince them that their interests will be promoted by the proposed changes; and this is not the work of a day.

In the review of emerging issues in active learning Sutherland in 1966 (as cited in Bonwell and Eison, 1991) listed several reasons for the hesitation in adopting active learning techniques in college classrooms such as faculty evaluation by students and the administration, classroom environments, assessments in both institutional and class level, and the need for more supporting resources. Bonwell and Eison (1991) highlight five (5) important barriers in adopting active learning strategies: inability to cover content, time
required to prepare for classes, inability to use in large classes, lack of materials and resources and the risk of evaluation by students and peer instructors.

Content, time factor, materials and resources. Transfer of information in a one-way path from teacher to student is less time consuming compared to a more two-way or rather multi-way path of discussion and arguments. Thus, a common criticism of active learning instructional model as indicated by Bonwell & Eison (1991) is its inherent tendency to take more time than a traditional lecture model to cover the same content. The need to spend more time in preparing and delivering an active learning method of instruction can inhibit educators from trying and testing its benefits. For a high quality professional development, more research need to be done in this subject of implementing active learning (Slavin, 1995). So, one of the main challenges is to device an active learning strategy that not only enhances the experience and effectiveness but also doing it within the same time period as a regular lecture format - How can active learning concepts be incorporated in a design curriculum to enhance the teaching and learning experience of the teachers and the students without a huge shift from the conventional methods of instruction?

Documentation of critical thinking & curricula integration. Most cooperative active learning models typically provide guidance to incorporate cooperative learning and do not provide actual materials. There is a need for development and research where cooperative learning and curriculum intersect (Slavin, 1995) - a need for development of high-quality well-developed, well-researched cooperative curricula in many subjects and grade levels, especially at the secondary level. Most cognitive research measures report grades, exam scores and testing procedures with little documentation that these measures assess critical
thinking (Cooper & Robinson, 1998) which might be very important in understanding the true effectiveness of the student learning.

**Assessment/evaluation by students and institution.** Student assessment of Active Learning strategies is also vital in encouraging the instructors to continue using them. Student comments on their learning experience can be a strong testimony to the liking or disliking of a new venture and will also be a means of improving the same. Convincing others to adopt active learning techniques and the institutions to accept it will be possible with a more concrete evidence of student performance by statistically analyzing the quantitative data gathered in a systematically conducted research, including qualitative analysis of student comments and also through a well documented research (Slavin, 1995).

To summarize, in order to address the barriers listed in Active Learning discussion, the main criteria that needs to be addressed is the time factor, content of the instructional module, and also the ease with which an instructor can modify a conventional lecture module into a more active learning module (i.e., achieving active learning benefits with minimal or no change in the time involved both in preparing and delivering the instructional module). This is a challenge, but if addressed effectively may encourage more instructors involved in undergraduate education to test the benefits of active learning strategies in their respective courses to address the various levels of cognitive thinking.

This thesis has been envisioned as an attempt to focus on a portion of the research agenda listed by Bonwell and Eison (1991) and Slavin (1995) through various means: refining the daylighting lecture module with subtle changes into an active learning module; conducting quantitative and qualitative testing and analysis of the daylight course module
effectiveness; testing long term impact of the modules in other courses; testing students at the six levels of cognitive thinking and having the direct involvement of the course instructor in the instructional research process.

Research Questions

The following research questions evolved from the review of literature, to be investigated in this research project:

1. Do students under a student-centered active learning strategy show more effectiveness in the convergent thinking levels of knowledge, comprehension and application of design facts compared to students under the teacher-centered traditional lecture?

2. Do students under a student-centered active learning strategy show more effectiveness in the divergent thinking levels of analysis, synthesis and evaluation of design concepts compared to students under the teacher-centered traditional lecture?

3. Do students under a student-centered active learning strategy show more effectiveness in going beyond explicit requirements in applying the acquired design acumen even outside the context of the course compared to students under the teacher-centered traditional lecture?

4. Do students experiencing a student-centered active learning strategy reveal more interest in the general conduct of the instructional session and the learning process compared to students under the teacher-centered traditional lecture?

These questions have been aimed at understanding the effectiveness of student learning under the two different instructional methods, lecture and active learning. They have served to guide every step of the research process including the overall design of the
research methodology, assessment criteria, evaluation process and analysis of the research results.

Objectives

The following four objectives were very crucial in determining the direction, design and conduct of this research:

1. To device the instructional modules and mode of conducting the sessions for both the lecture and active learning methods.
2. To develop and assess the effectiveness of an active learning strategy based on Bloom’s Taxonomy in a non-studio session in comparison with a traditional lecture format.
3. To study the effectiveness of the instructional methods in helping students apply the gained design information within & outside the course context.
4. To study the student thought and common perceptions on the active learning and lecture instructional models to understand the student expectations and experiences in the context of undergraduate education.

Summary

There was minimal information and research found on an easier transition from conventional lectures to a relatively more active learning strategy and this thesis attempts to address this issue and also study the effectiveness of the active learning method in the interior daylighting session without compromising on the course content and the time spent. The next chapter will detail the hypothesis and the research methodology used to generate and analyze data for testing the hypothesis.
CHAPTER 3: METHODOLOGY

Methodology can be defined as the methods used to collect information (McMillan & Schumacher, 1997). The way research is conducted impacts the results and hence detailing the exact methodology used in the research to its finest details helps establish a framework within which the research can be analyzed (Slavin, 1995). While the literature review established the reasoning for conducting the research, the methodology clarifies the means used to conduct the research. Though the circumstances of a research changes every time it is repeated, only with a clear explanation of the methodology can a researcher repeat the research to the closest accuracy on a future date. McMillan and Schumacher (1997) explain that most studies address different factors that contribute to the quality of the information collected to demonstrate to the readers of the research, that appropriate steps have been taken to ensure accurate information. It is the full documentation of the steps taken while conducting the research that eventually determines the limitations of the research and hence the interpretation of the research analysis results. Thus, this chapter is intended to provide this full documentation of the research process.

Overview

The purpose of this study is to compare the effectiveness of Active Learning (AL) instructional method with conventional Lecture (L) instruction in a day lighting module within an interior design course. The intent of the study was to investigate whether there are any significant effects in the students’ performance and learning experience from an active learning student-centered focus compared to a conventional teacher-centered lecture focus. In this study, an AL instructional method was used for one group, while a conventional L format was used for the control group. For both groups the understanding and application of the daylighting information was tested at different levels of cognitive thinking, based on
Bloom’s taxonomy (Bloom, et al., 1956). The aim of the study is to compare the effectiveness of the two instructional methods on the learning experience of students and the students’ ability to apply the gained information outside the immediate daylighting module context. Identical pre- and post-tests were administered to both groups. This chapter describes the methodology that was used in the study to provide an understanding of how the research was conducted and the reason for the same.

Statement of Hypothesis

Based on the research questions discussed in chapter 1 and the literature review in chapter 2, the following hypothesis was developed:

Hypothesis 1: Effectiveness of instruction, lecture and active learning, in the daylighting module

$H_1$: There is a significant difference in the effectiveness of instruction of the daylighting module between students involved in the AL method of instruction compared to students in the L method of instruction.

The effectiveness of the instructional interventions was tested based on Bloom’s taxonomy of cognitive thinking (Bloom, et al., 1956). The following are the four criteria identified as the operational means for testing the hypothesis:

Criterion 1 (CR 1): Student knowledge, comprehension, and application of daylighting information

There will be statistically significant greater evidence of knowledge, comprehension, and application of daylighting information for students experiencing an AL method of instruction compared to students in the L method.
Criterion 2 (CR 2): Student analysis, synthesis, and evaluation of information of daylighting information

There will be statistically significant greater evidence of analysis, synthesis, and evaluation of daylighting information for students experiencing an AL method of instruction compared to students in the L method.

Criterion 3 (CR 3): Student use of daylighting information in the appropriate context

There will be statistically significant greater evidence in ability to use daylighting information in an applied design project for students experiencing an AL method of instruction compared to students in the L method.

Criterion 4 (CR 4): Student impression on the learning process

There will be statistically significant greater evidence in interest for the learning process for students experiencing an AL method of instruction compared to students in the L method.

To summarize, the underlying presumption of the research hypothesis is that the AL method is more effective compared to the L format under the following criteria: Application of knowledge, comprehension, and application of daylight information; analysis, synthesis, and evaluation of daylight information; using daylighting information in the appropriate context and students’ interest for the learning process.

The current chapter further elaborates the research components that were used to test the hypothesis and the four related criteria. These include the courses involved, the curriculum, and the student participants’ profile. This is followed by an overview of the
research and how each of the elements fit together in a sequence. Each research quiz/exercise is then described in detail explaining the rationale, development, and scoring methods used. Next the conduct of the research is addressed in the research sequence elaborating the procedures for the actual testing. The chapter concludes with a list of data analysis methods used to statistically analyze the data collected from the research. The actual analysis of the data will be explained in chapter 4.

Research Setting

As implied in the Criterion 3 (CR 3): Use of information in the appropriate context, the research not only tests the effectiveness of the instructional methods, L and AL, within the concerned course of the interior design program but also the ability of students to transfer information across course boundaries. The research setting in this study can be described by two main factors: Research participants and courses involved in the research.

Research participants

Student participants were all majors in the Interior Design program in the College of Design at Iowa State University, Ames, Iowa. The students were simultaneously enrolled in two different courses in the interior design program. The student participants were in the second half of their third year of study in the interior design program; the students were all women (97.3%), with the exception of one male. There were 37 students enrolled in the Interior Materials Systems and Details IV (IMSD IV) course and 41 students in the Interior Design Studio IV (IDS IV) course. Since the nature of the research involved two different courses, the 37 students in the IMSD IV course were the effective number of students whose data were usable as part of the research. Due to the nature of the research and
student attendance on the presentation, research data collection and class sessions, not all students were involved in all or portions of the study.

**Courses involved in the research**

The research venue involved two interior design courses. The students were registered in both the IMSD IV and the IDS IV taught as late afternoon and morning sessions respectively on Tuesdays and Thursdays by different instructors during the semester of the research period.

**IMSD IV - Interior Materials Systems and Details IV.** It was a three credit course in the spring semester that met twice a week for two hours on Tuesdays and Thursdays in the afternoon. The students in this course had to be registered in IDS-IV and must have completed Interior Materials Systems and Details III. The Iowa State University Catalog ("Courses", 2005 - 2007) describes the course content of IMSD IV as follows:

"Exploration of concepts, materials, and assemblies associated with development of building construction. Discussion of common building materials and methods. Overview of electrical, mechanical, acoustical, other building systems. Emphasis on human factors, codes, detailing and other interior design issues related to buildings."

The students had regular readings for each class period and were administered short five minute multiple choice quizzes from the readings once a week. The students were instructed on various topics on interior materials systems and detailing through lectures during the class meetings. As part of the course requirement the students were also assigned a design project. They had to design a small live-in work space/ building for a client in a sloping campus site west of the College of Design.
**IDS IV - Interior Design Studio IV.** It was a four credit course in the spring semester that met twice a week on Tuesday and Thursday in the morning. The course had one hour of lecture or discussion time per week on Thursday and three hours of studio time on both Tuesday and Thursday. The students in this course had to have completed three previous technology courses and three design studios as well as three visual communication courses and two history of interior design courses. The Iowa State University Catalog ("Courses", 2005 - 2007) describes the course content of IDS IV as follows:

"Emphasis on three-dimensional spatial development in large scale, multiple scale unit institutional projects. Inclusion of extensive design documentation. Expansion of alternative manual and computer based visualization methods. Teamwork."

The class was divided into two sections located in adjacent studio rooms, meeting at the same time. Students worked in their design studio under the guidance of two instructors. The students worked as teams for their assigned design projects and both sections of the class met as one group once a week to discuss issues and for general information transfer with the instructors. There were no formal tests or exams for this course and each student team worked on one design project from a choice of four. The course had intermediate submissions dates for construction documents and a final submission of the entire project at the end of the semester.

**Research components and sequence**

A brief description of the components of the research and how they fit together as a sequence provides an overview for the subsequent detailed account of each component and the procedure used to administer them. The research design with activities like quizzes,
exercises, instructional modules, design reviews and student impression were sequenced as follows (see Figure 2).

The quizzes and exercises designed for the research were pilot tested with voluntary students of interior design not directly involved with the research, to refine and modify the research test content and questions for any inadequacies.

Data collection occurred in the spring 2006 semester after pilot testing and receiving human subject approval (see Appendix A) for the research from the Iowa State University (ISU) Institutional Review Board. Before the pre-tests, the students in IMSD IV were randomly assigned to two different groups, Lecture (L) and Active Learning (AL). Students were told of the grouping a week before the instructional intervention, but were not informed about the difference in the instructional approach for the two groups.

The entire class participated in two pre-test measurements: Interior Design Analysis exercise (B1-IDA) in the IDS IV and Interior DayLighting quiz (B2-IDL) in the IMSD IV. The “intervention” instruction was interior daylighting delivered in IMSD IV by the course instructor on two separate days in the same week. Group L received instruction with a conventional, teacher-centered lecture and group AL received a learner-centered, active mode of instruction. After the interventions or daylighting instructional sessions, all students in the class were simultaneously administered two post-tests (A1-IDA and A2-IDL) in IDS IV and IMSD IV respectively. Student design projects (DP) of IMSD IV were individually analyzed for application of daylighting principles in the design proposals. As a final research activity students were requested to briefly write their reflection (SR) and comments on the interior daylighting instructional session that they experienced.
The research sequence can be summarized using the notational system of 'pre-test-post-test comparison group design' (McMillan & Schumacher, 1997) (see Figure 2).

Figure 2. Research design: Pre-test–post-test comparison group design

**Student Groups for research**

- **R** - Random group assignment
- **L** - Teacher-centered conventional Lecture group
- **AL** - Learner-centered Active Learning group

**Pre-test measurements**

- **B1-IDA** - 1\textsuperscript{st} Before treatment Interior Design Analysis exercise
- **B2-IDL** - 2\textsuperscript{nd} Before treatment Interior DayLighting quiz

**Interventions** (*X_n – Treatment conditions; subscripts indicate different treatments)*

- **X1-L** - Interior Daylighting Lecture Intervention
- **X2-AL** - Interior Daylighting Active Learning Intervention

**Post-test measurements**

- **A1-IDA** - 1\textsuperscript{st} After intervention Interior Design Analysis exercise
- **A2-IDL** - 2\textsuperscript{nd} After intervention Interior DayLighting quiz
- **DP** - Student Design Project
- **SR** - Student Reflection (on daylighting session)
Description of research data components

The intent, design, development, final handout, and scoring method for each of the four data collection components are described in this section. The criteria that were used to include or eliminate the data of some of the research participants are also discussed. To avoid influencing the research results, the inclusion and elimination of data were not discussed with the students and all students in the IDS IV course were encouraged to take part in the research. As the research quizzes, design project review, and student reflection within IMSD IV were well integrated in the course structure, the students were not aware of these as research procedures.

The data components used in this research were:

IDA – ‘Interior Design Analysis’ exercise: (Conducted in IDS IV Course)
IDL – ‘Interior DayLighting’ quiz: (Conducted in the IMSD IV Course)
DP – ‘Design Project’ review: (Project from IMSD IV Course)
SR – ‘Student Reflection’ write-up: (Conducted in IMSD IV; on the daylighting session)

Interior Design Analysis exercise (IDA).

The IDA exercises were designed to evaluate the content of a student’s analysis and critique of an interior design space. Since most of the information and communication in the building industry is through images and diagrams, design students need to have a keen eye to visual information and analyze a design for its key concepts. The IDA exercise attempted to measure this aspect of design education and tried to understand the level of student awareness of the sustainable design aspect of daylighting in the given image. These
analysis exercises were designed to test the students’ ability to apply learned concepts to another course context.

The choice of the interior space image for the IDA exercise was driven by the use of daylight and the apparent importance of lighting in the design. The exercise was intended to measure the level of importance students gave to daylight and lighting in general as interior design features (see Appendix B). The interior space selected was the ‘Thought Bubble’ Philology library, at the Free University, Berlin, Germany designed by Norman Foster Architects (Makovsky, 2006). One of the primary design features in the space was the huge translucent bubble roof form of the library that admits huge amounts of daylight into the interior space. In order to clarify this translucent quality of the roof, minimal image editing was used to add tree images outside. The image also showed other lighting design aspects in the library space including task lighting, interior surface color choices, etc.,

The IDA exercise directed the students to identify and discuss the design concepts incorporated in the interior space image. They were asked to list four keywords they felt were evident in the image and to briefly discuss/critique/analyze each keyword. As the intent of the exercise was to test the student’s identification of daylighting concepts in the assigned space and to avoid research bias, the question was framed as an open-ended question with no specific suggestions/choices referencing daylighting.

The IDA exercise handout had a 5x3 color image of the interior space to be analyzed and a 2 x 4 grid chart for recording the keywords and analysis on one page. The handout clearly allocated areas for writing the student responses and also accommodated a random-id number, to be created by the individual students. For better clarity, a bigger print-out of
the same image was included as a second page in the exercise handout. The handout was designed to be folded, closing the student responses from immediate view of others. (see Appendix B and C for the exercise and an image of the handout design)

Two different criteria were established for the evaluation of the IDA exercise. While the first evaluation was the number count of occurrences of daylighting concept in the student responses, the second evaluation scored the evidence of thoroughness of daylight discussion. A scoring rubric, ranging between scores 0 to 4 with increments of 1, was used to evaluate the thoroughness factor. The general scoring rule used was 0 for a strong disagreement, 2 for neutral response, and 4 for a strong agreement that “there was evidence of thoroughness of daylight discussion.” Depending on the individual circumstance, scores of 1 and 3 were also used. The procedure followed for the evaluation of the IDA pre- and post-tests will be explained in detail in the procedures section of this chapter (see Appendix D).

**Interior DayLighting quiz (IDL)**

Sustainable design is a very important subject in design education that should be conveyed in the best possible means. Students’ design acumen of the subject is very crucial (Sterling, 2004). The IDL quiz was intended to study the students’ level of understanding of interior daylighting design concepts integral to sustainable design. An IDL quiz was conducted to examine students’ cognitive thinking levels before and after the instructional intervention. The daylighting quizzes were designed to test the students’ ability to go beyond memory recall into higher order thinking. The IDL quiz design was based on Bloom’s taxonomy of cognitive thinking, discussed in Chapter 2. Comprised of 6 questions, the quiz addressed each level of cognitive thinking: knowledge, comprehension, application,
analysis, synthesis, and evaluation (see Appendix E and G). The composite of the questions was also designed to include most of the important issues of daylighting.

Since questions 1 and 2 were knowledge and comprehension level questions the subject content could not be matched between the tests in order to avoid repetition of quiz questions. For Questions 3 to 6, both the pre and post-tests question subject contents were matched for each cognitive level. For example, Question 5 in both the pre- and post-tests addressed the same daylighting issue of brightness contrast ratio. Though the actual questions varied they were on the same subject and at the same cognitive thinking level of ‘synthesis’. A quick overview of the content and cognition level of the questions in both the Daylighting quizzes is as follows. (see Appendix E and G for the quizzes)

**IDL pre-test questions.**

Q1: Daylight sources (Knowledge)
Q2: Window shades - Blinds in east wall (Comprehension)
Q3: Sun angles – Indicate on building section and plan (Application)
Q4: Interior surface reflectance (Analysis)
Q5: Brightness contrast ratio – Computer station lighting design (Synthesis)
Q6: Daylight, electrical layout and circuiting options (Evaluation)

**IDL post-test questions.**

Q1: Solar chart variables (Knowledge)
Q2: Daylight in Australia – Solar wall (Comprehension)
Q3: Sun angles – Explain the design of the building section (Application)
Q4: Interior surface reflectance (Analysis)
Q5: Brightness contrast ratio – Computer and windows (Synthesis)
Q6: Daylight, electrical layout and work desk orientation options (Evaluation)
The IDL quiz is an 8 ½" by 11", two-page, 4-sided handout with question types including multiple choice, short answers/explanation, and a drawing exercise. Enough space was allocated for student responses within the test booklet. As quizzes were a normal part of IMSD IV, the format of this component emulated the normal course quiz format with spaces allowed for students to identify their responses and write in their name (see Appendix E and G).

A scoring rubric, ranging between scores 0 to 4 with increments of 1, was used for the evaluation of the IDA quiz. The general scoring rule used was 0 for an incorrect answer, 2 for partially correct/incorrect answer, and 4 for a correct answer. Depending on the individual circumstance, scores of 1 and 3 were also used. The procedure followed for the evaluation of the IDL pre- and post-tests will be explained in detail in the procedures section of this chapter (see Appendix F and H).

Design Project (DP)

The DP review for IMSD IV was designed to analyze students’ application of daylighting design information in their respective design projects. Information given to the students in the course was intended to be used in their design projects. While the majority of the consolidated information was from the instructor, it is the ability of students to transfer the information into a design context that becomes a prime necessity in design education. The DP review of the students’ IMSD IV final project attempted to measure this aspect of design education. The students worked on a residential design project in the course. This research tried to evaluate the application of daylighting principles and to understand the level of student awareness of the sustainable design concept of daylighting as revealed in their projects.
Since the design project reviewed was part of the IMSD IV course requirement, the researcher did not design the exercise or handouts. The projects were reviewed by the researcher after their submission to the instructor at the end of the semester.

Three different criteria were established for the evaluation of the DP review. Two evaluations were number counts for occurrences of daylighting concept in the student responses; the third evaluation scored the level of integration of daylighting in the design solution. The number count for occurrences of a daylighting concept in the students’ design projects was based on their explicit use of the concept. A separate Researcher count (R.Ct) was done with the researcher identifying design features that could be categorized as daylighting concepts.

A scoring rubric, ranging between scores 0 to 4 with increments of 1, was developed to evaluate the thoroughness factor – the level of integration of daylighting concept. The general scoring rule used was 0 for a strong disagreement, 2 for neutral response and 4 for a strong agreement that daylighting was well integrated in the design solution. Depending on the individual circumstance, scores of 1 and 3 were also used. The number count for the number of occurrences of daylighting concepts in the design project did not have a pre-set target value. Depending on the extent to which students incorporated the concepts, the number counts were expected to be zero and above.

The procedure followed for the evaluation of the DP review will be detailed in the procedures section later in this chapter (see Appendix J). The criteria for evaluation can be summarized as follows:
1. Number of occurrences of daylighting concept in the students project (Explicit daylight use seen in the text) – Number count

2. Number of occurrences of daylighting concept in the students project (Implicit daylight usage as seen by the evaluator- either as a deliberate design choice or a design by chance) – Number count

3. Daylight integration in the design solution. (Looks at the design project for its true adherence to daylight principles and not just relying on verbal design objectives) – Scoring rubric ranging from ‘strongly disagree’ (0) to ‘strongly agree’ (4)

*Student Reflection write-up (SR)*

While quantitative research helps suggest the existence or non-existence of a relationship between various factors in an instructional classroom, the first hand reflection of students’ thoughts and reactions can be an important qualitative research indicator in understanding the subjective, experiential aspect of the instruction. This can provide valuable clues that can be used to improve the effectiveness of an instructional method. The SR write-up exercise was intended to provide such review from the students about the daylighting session in the IMSD IV course.

The students were given a handout titled ‘Reflection on daylighting session’ with space to write comments on the daylighting session. Though the research was interested in comparing the effectiveness of the L and the AL methods, no leading statements or questions were included in the handout. The question was open-ended to generate spontaneous responses of the students about their experience. Space was provided for students to indicate the date of the daylighting session they attended, to associate the students’ response with the corresponding instructional intervention (see Appendix P).
The students’ reflections were analyzed using text content analysis. The various reactions of students were grouped based on the issue that was addressed in each comment to create a cohesive list of students’ reaction. A number count of responses for each of those issues for the two groups was tabulated and analyzed. A detailed account of this analysis will be developed in Chapter 4.

The four components, designed to collect data for the research, underwent several reviews and subsequent modifications to effectively address the research question. The development of the daylighting instructional modules, its content and design, are explained in the following section.

Daylighting instructional module

The student participants had a session on daylighting in their lighting course the previous semester and some students were also actively involved in the Emerging Green Builders organization at ISU. Since daylighting is a vast topic and a two-hour session was the only compulsory course venue in which the students would receive daylight information this semester, basic concepts of daylight were addressed in the instructional modules. The researcher prepared the instructional modules and reviewed the content with the IMSD IV course instructor. Together they made appropriate refinements in the content and its proposed delivery. Apart from the general content of the module, the various activities and the time taken for each in the AL module were discussed and a reasonable number of activities were selected for the session. Some of the researcher’s suggestions to the course instructor for application in conducting the active learning discussions in the AL module included: discussion conducting strategies, instructor role in discussions, and student activities (see Appendix N).
Content

The content for the daylighting modules was designed as a stand alone set of information that could serve as a seminar in daylighting outside the context of the course as well (see Appendix L and M). The session on daylighting in interior design addressed the main topics that were administered by the IMSD IV course instructor to both the L and AL groups.

The following topics were selected based on the literature review:

1. Importance of daylight – What? & Why?
   Definition of daylighting, reasons and benefits of daylight including psychological, physiological and energy issues. Specific goals in daylighting buildings.

2. Sources of daylight – From where?
   Primary and secondary sources of daylight.

3. Availability of daylight – How much?
   Significance of project location: Sun angles, building orientation and time.

4. Daylight distribution and interior elements
   Interior surface reflection: Surface quality, angles and room proportions – The various interior design elements and features that influence the distribution of daylight within the interior space.

5. Daylight integration with other building systems
   Importance of linking daylight design with other building systems like electric lighting. Building fenestration and daylight contours, daylight zones, integrated electric light design, fenestration controls, and lighting controls like sensors.

6. Daylight performance issues
   The design and performance issues in the effective use of daylight like brightness contrast ratio, glare, veiling reflection, and heat gain.
7. Daylighting case study

Interior design analysis of a daylit space.

Criteria for intervention design

Some of the important criteria in the planning of the L and AL daylighting instructional interventions were:

1. Time duration for both sessions should be a constant: This was crucial as the general characteristic of any active learning method, which is also considered as its downside, is the time factor involved in the entire process. This concern for keeping the time constant helped establish the use of active learning methods that would not extend the basic time for information delivery.

2. Few minor changes/ modifications in techniques should be the norm for switching between the two intervention modules to encourage instructors to try a different instructional method: This approach would be helpful in establishing the possibility of easy modification of any conventional lecture method of presentation into an active learning method of instruction.

3. The research would stay true to the existing practical restrictions including the two hour class session: A two hour session was determined to be the only available time for interior daylighting course information within the course curriculum: Answers to the pre-test IDL quiz questions (B2-IDL) would be integrated in the daylighting module.

4. The research should have a low profile: Since the lecture mode of instruction was the norm for the course, to avoid cross-contamination between groups, the L intervention was scheduled on Tuesday followed by the AL intervention on Thursday in a single week.
5. The daylighting session should be part of the course and not be seen as a special thesis research activity: To study the natural attitudes and responses of students, the research setting needed to appear to be a normal part of the course.

Based on these criteria, the procedures that were followed to conduct the research, including the data collection, the daylighting instructional intervention, and the data analysis are explained in the following section.

Testing procedure

The research was conducted in the second half of the spring semester 2006 within a period of 36 days, from March 30th to May 4th. The pilot tests were conducted in the last week of February.

Pilot testing

The quizzes and exercises were pilot tested before administering them to the research participants. Interior design students who were not directly involved with the research were asked to participate. Two senior interior design students and three graduate interior design students volunteered to pilot test the research quizzes and exercises. In administering the components, the researcher explained that the testing was for a research project and that the results and the students' feedback were to be used to refine and modify the quiz and exercise content. Since the students were not involved in the instructional interventions, the pilot tests were conducted for the IDA exercise and IDL quizzes only. The pilot tests proved to be useful in correcting mistakes and misinformation that may have caused unintended confusion and misunderstanding of the quiz and exercise questions.
Human subjects approval

The Human Subjects Review Committee in the Institutional Review Board, IRB, of the University reviews any research involving human subjects including proposals to gather data from subjects for theses, dissertations and other student projects ("Human Subjects", 2006). The researcher took Iowa State University’s online Human Subjects training and test. A Human Subjects application was submitted to the IRB with the research objectives, benefits, research plan, participant selection, consent process, data storage, analysis methods, confidentiality statements and the educational tests that would be part of the research. Since the research was planned for an educational setting using educational procedures, student participant identities were to be kept confidential and was under constant peer review (i.e., faculty thesis committee), the research was exempt from other regulations and received the consent of the IRB (see Appendix A).

Interior Design Analysis pre-intervention exercise (IDA)

The IDA exercise was completed during a regular weekly lecture session that was part of IDS IV. As arranged with the design studio instructors the exercise was completed in the 12th week of the semester. After a verbal introduction to the research and gaining the verbal consent of the students, the one page IDA exercise was distributed. The duration of the exercise was 15 minutes (see Appendix B and C).

The students were asked to write a random - alphabet and a two digit number id on their exercise paper and on a class list when submitting the exercise. [The random-ids corresponding to the student names were used for data analysis only and student identities were kept confidential in the research]
**Interior DayLighting pre-intervention quiz (IDL)**

The daylighting pre-intervention quiz was administered by the instructor in IMSD IV. It was conducted like the other regular quizzes in the course, except that it was not pre-announced. As the intention of the study was to understand the effects of the instructional intervention that was to follow, students became aware of the quiz only at the start of the class on Thursday of the 11th week of the semester (see Appendix E).

**Instructional interventions: Lecture and Active learning (X1-L and X2-AL)**

The subject of interior daylighting was presented to the students as two different instructional interventions: Lecture (X1-L) and Active Learning (X2-AL). The two instructional methods were respectively used on Tuesday and Thursday in the fourteenth week of the semester for the control and experimental group of students respectively. The week prior to the instructional interventions, the students were informed of their random group assignment and the day their group would be meeting. The group list was posted in the junior year interior design studios and students received an email from the course instructor with the list. In the email, students were asked to work on their course design project on the day they were not attending their assigned instructional session. There was no mention that the instructional approach to the topic would be different.

Initially the L and AL two-hour sessions were each designed to be split between the two days in the fourteenth week of the semester as two one-hour sessions on Tuesday and Thursday, with the L group attending the initial one hour followed by a one hour session with the AL group. Though this sequencing would have maintained a consistent time factor between the pre- and post-intervention quizzes and the instructional intervention, this schedule did not work well for either the instructor or the students: the instructor would have
had to repeat the same information twice, back to back within the two-hour session and there would have been a high chance of student interaction and discussion immediately before and after the sessions. To avoid these potential problems, the intervention sessions were conducted Tuesday and Thursday for lecture intervention and active learning intervention respectively.

**Lecture (X1-L).** The L method of instruction was based on a Microsoft PowerPoint presentation, developed by the researcher. The “slides” and related content were reviewed with the instructor before the actual session to clarify any ambiguities. The presentation was self explanatory with all the necessary delivery content found in the slides. A copy of the entire presentation was printed out for the instructor’s convenience (see Appendix L). Nineteen (19) students were assigned to this session and 17 students attended the lecture.

**Active Learning (X2-AL).** The Microsoft PowerPoint presentation was used in this session, but was modified slightly to adhere to the active learning method (see Appendix N). The main learning activity used in the session was team work and discussions. The five (5) slides (see Appendix M) that were to be part of the discussion activity were coded with a black stripe for easy identifying by the instructor. Eighteen (18) students were assigned to this session and 17 students attended the session. The first slide in the PowerPoint presentation showed a list of 6 teams of 3 students each which had been assigned by a simple grouping from the class list. The students were requested to reseat themselves as teams for the class activities. A list of activities and corresponding discussion times was provided for the instructor’s reference (see Appendix N).
Interior DayLighting post-intervention quiz (IDL)

The procedures were the same as the IDL pre-intervention quiz (discussed earlier), but this quiz was conducted after the daylighting instructional intervention in IMSD-IV. The exercise was administered on Thursday of the week following the daylighting sessions (week 15) and students were not informed of the test ahead of time (see Appendix G).

Interior Design Analysis post-intervention exercise (IDA)

The procedures were the same as the IDA pre-intervention exercise (discussed earlier), but this exercise was conducted after the instructional intervention in IDS-IV. The exercise was administered in the final week (week 16) of the semester which was the last meeting for IDS IV. To avoid discrepancy in the choice of image for the interior design analysis, the same image that was used in the pre-intervention IDA exercise was also used for the post-intervention IDA exercise. The students were requested to analyze the image of the interior space and to write their analysis as detailed as possible (see Appendix B and C).

Design Project (DP)

The student design projects were displayed on the college corridor walls for their course evaluation (IMSD IV). The projects were evaluated by the researcher in the same sequence as they were displayed in the wall. While the projects were reviewed in their entirety, the key evaluation was ‘daylighting’. The projects did have the names of the students, but the researcher noted each project using alphabet identifiers. After the evaluation, student names were noted for each project alphabet, which was later related to the instructional group during data analysis. Since the students had a choice of working on the design project in groups or individually, the effective data that could be used for the analysis was reduced.
The composition of student teams could be categorized as:

Category 1: Members are only from Lecture treatment group

Category 2: Members are only from Active Learning treatment group

Category 3: Members are from either Lecture or Active Learning treatment group

After the design project for IMSD IV was introduced at the beginning of the semester, several teams of different sizes were immediately formed by the students. Thus the researcher had no control over the size or distribution of the student teams. In the evaluation of the design projects of category 3 teams, it will be difficult to separate the contributions of students from the two instructional groups, L and AL, to the design project. For better analysis and interpretation of the effectiveness of the instructional methods, student teams from category 3 were eliminated from this portion of the study. The projects of the remaining six teams in each of the intervention types, L and AL, were analyzed for evidence of inclusion of both written form and visual daylighting concepts.

*Student Reflection write-up (SR)*

As a final course activity on the last class meeting during finals week (16th week), students were requested by the IMSD IV course instructor to briefly write-up their reflection (SR) and thoughts on the daylighting sessions that they experienced (see Appendix K for the SR handout).

*Research tests evaluation*

The evaluations of the visual research data components required coding the student responses and were conducted by either the researcher or College of Design professors (see Table 1).
<table>
<thead>
<tr>
<th>Research tests</th>
<th>Evaluator(s)</th>
<th>Evaluation Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>IDA – Interior Design Analysis (Pre- and Post-intervention exercises) Interior Design Studio IV (IDS IV) course</td>
<td>Two professors in College of Design (experienced professors in teaching lighting and daylighting)</td>
<td>Conducted after the end of the semester in a meeting room in College of Design. The two instructors initially checked their consistency in evaluations on sample tests and then completed the evaluations of both pre- and post-tests.</td>
</tr>
<tr>
<td>IDL – Interior DayLighting (Pre- and Post-intervention quizzes) Interior Materials Systems and Details IV (IMSD IV) course</td>
<td>Researcher – researched on this subject for the thesis and had the guidance of the thesis advisor during the process.</td>
<td>The researcher blind reviewed the pre- and post-tests after the semester ended and it was randomly checked for correctness by the thesis advisor.</td>
</tr>
<tr>
<td>DP – Design Project Interior Materials Systems and Details IV (IMSD IV) course</td>
<td>Researcher under the guidance of thesis advisor.</td>
<td>The researcher evaluated the design projects displayed as student teams and then related the scores to the student names for data analysis.</td>
</tr>
<tr>
<td>SR – Student Reflection Interior Materials Systems and Details IV (IMSD IV) course</td>
<td>Researcher under the guidance of thesis advisor.</td>
<td>The researcher analyzed the text of the student write-up and formulated the core ideas and thoughts expressed by the students. A number count on each of those ideas was then performed.</td>
</tr>
</tbody>
</table>

Table 1. Research component evaluation summary: Evaluators and method of evaluation

*Data analysis*

Data analysis is the process of simplifying quantitative or qualitative data for better understanding, involving application of statistical techniques to numerical data or coding and finding patterns or themes in narrative data (Gay & Airasian, 2003). Data collected from the research components and subsequent evaluations were analyzed using the SPSS 13 statistical analysis software. The analysis used 0.05 significance level ($p=0.05$) (Fraenkel & Wallen, 1993) and included statistical tests like independent t-tests, frequency distribution and inter-rater reliability analysis. The analysis looked at the differences between groups in
each of the exercises and also cross-referencing between exercises. Since the research project also tried to find information transfer between courses, the student performance in each of the exercises are studied in relation to their instructional method and daylighting quiz performance. The research data components and the corresponding data analysis used in the project are:

**IDA - Interior Design Analysis exercise:**
- Inter-rater reliability test (Cronbach’s alpha test)
- Independent t-test for the pre- and post-test comparison between the groups

**IDL - Interior DayLighting quiz:**
- Frequency distribution analysis to compare the overall group performance
- Independent t-test for the pre- and post-test comparison between the groups
- Independent t-test for the gain score comparison between the groups

**DP - Design Project:**
- Independent t-test for score comparison between the groups
- Graphical analysis for comparing group scores for higher order daylighting quiz and the design project

**SR - Student Reflection on the daylighting sessions:**
- Qualitative text analysis of tabulated student responses

The results of this analysis are explained in detail in chapter 4.
CHAPTER 4: RESULTS

Overview

The study researched the effectiveness of active learning compared to a conventional lecture delivery of an interior design instructional module on daylighting. Three quantitative analysis instruments and one qualitative text analysis measurement instrument listed below were used to compare the effectiveness of the two instructional methods.

Measurement instruments

1. IDL – Interior Day Lighting quiz was used as pre- and post-tests to compare the students’ understanding of the daylighting concepts. Student understanding was measured based on the six cognitive levels of thinking proposed by Bloom et al. (1956).

2. IDA – Interior Design Analysis pre- and post-test exercises provided a basis for studying the effect of a daylighting instruction module outside the context of that course.

3. DP – Design Project review was used to determine the extent of application of daylighting principles in the students’ summative design project of IMSD IV.

4. SR – Student Reflection write-up was a short open-ended response form completed by the students about their learning experience in the daylighting module.

As noted in Chapter 3, the statistical analysis software SPSS 13.0 for Windows was used to analyze the data. The results of the analysis are presented in this chapter and are discussed with respect to the research hypothesis in Chapter 5: Conclusion.
Measurement 1: IDL – Interior DayLighting quiz

IDL pre-test data was collected to determine the existing knowledge base of the students prior to exposure to the instructional module on daylighting. To create a statistically viable grouping, the students were randomly assigned to the instructional groups for the interior daylighting instructional intervention using a statistical random number table as explained in Chapter 3.

The variables used in the IDL Quiz data analysis have the following abbreviation key:

GRP - Group
Q – Questions
B – Before (Pre-test administered Before the instructional intervention)
A – After (Post-test administered After the instructional intervention)

Examples & explanations:

BQ1 – Pre-Test (B) Question (Q) number 1
AQ6 – Post-Test (A) Question (Q) number 6
Bavg1_6 - Pre-Test (B) Average (avg) of questions 1 to 6 (1_6)
Aavg1_3 - Post-Test (A) Average (avg) of questions 1 to 3 (1_3)

Diff_Q1 - Difference in pre & post test scores (Diff) in Question1 (Q1)

Diff_x_y - Difference in pre & post test scores (Diff) in average of questions x to y (Eg: Diff_ 1_3 include questions 1, 2 & 3)

Diff_all - Difference in pre & post test scores (Diff) in average of all questions
Interior DayLighting quiz– IDL pre-test: Base scores

The mean scores of the IDL pre-test of both the groups differ by only 0.0898 (Lecture GRP: $M = 2.26$, $SD = 0.45$; Active Learning GRP: $M = 2.35$, $SD = 0.77$). An independent t-test of the between-groups pre-test variable, Bavg1_6 ($p = .72$) indicates there is no statistically significant difference between the pre-test scores of the two groups of students. Thus it could be concluded from the IDL pre-test mean scores of the daylighting knowledge, the two groups of students is similar as evidenced by this test (see Figure 3). But the graph shows an explicit difference in distribution of student scores. While the AL group scores are distributed well across the scoring chart, the L group has a small distribution of scores with a standard deviation of .45.

![Figure 3. Frequency distribution of IDL overall pre-test scores: Lecture group (n=13) and active learning group (n=13)](image)

To compare the two student groups (L & AL) in detail, independent t-tests were conducted for each of the 6 IDL pre-test questions (BQ1 to BQ6) that addressed the 6 levels of cognitive thinking (Bloom, et al., 1956). Average of the convergent thinking questions of knowledge, comprehension, and application (Bavg1_3) and average of the divergent
thinking questions of analysis, synthesis, and evaluation (Bavg4_6) were also analyzed to determine the statistical difference in the performance of the two groups.

Neither the convergent nor the divergent thinking questions mean scores (Bavg1_3 and Bavg4_6) with p=0.21 and p=0.32 respectively show a statistically significant different between the two groups (see Table 2 for the group scores in the question categories and the corresponding statistical significance values).

<table>
<thead>
<tr>
<th>IDL Pre-test - Question categories</th>
<th>Lecture</th>
<th>Active learning</th>
<th>P value : Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bavg1_3: Convergent Thinking</td>
<td>1.74</td>
<td>2.05</td>
<td>0.21</td>
</tr>
<tr>
<td>(Knowledge, comprehension &amp; application questions)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bavg4_6: Divergent Thinking</td>
<td>2.77</td>
<td>2.64</td>
<td>0.32</td>
</tr>
<tr>
<td>(Analysis, Synthesis &amp; Evaluation questions)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* indicates .05 or more significance
Higher of the two mean scores is highlighted in each question category

Table 2. Mean scores for IDL pre-test convergent & divergent thinking questions and p-value for difference between the two groups

When looking at the individual questions, the mean scores of the IDL pre-test evaluation level question, BQ6, had a group difference of 0.54 (L GRP:: $M = 2.38$; AL GRP:: $M = 2.92$). An independent between-groups t-test of this variable, BQ6 ($p = .04$) indicates a statistically significant difference in between the groups on this question. The comprehension level question, BQ2, shows tendency toward a significant difference ($p=.0505$). The other four questions do not indicate a significant difference in the performance of the two groups (see Table 3 for group scores in the individual IDL pre-test questions and the corresponding statistical significance values).
**Table 3. Mean scores for each group for each IDL pre-test questions and p-value for difference between the two groups**

<table>
<thead>
<tr>
<th>IDL: Pre-test Questions</th>
<th>Lecture</th>
<th>Active learning</th>
<th>p value : Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>BQ1: Knowledge Question</td>
<td>2.77</td>
<td>2.77</td>
<td>0.50</td>
</tr>
<tr>
<td>BQ2: Comprehension Question</td>
<td>0.92</td>
<td>2.15</td>
<td>0.0505</td>
</tr>
<tr>
<td>BQ3: Application Question</td>
<td>1.54</td>
<td>1.23</td>
<td>0.31</td>
</tr>
<tr>
<td>BQ4: Analysis Question</td>
<td>2.92</td>
<td>2.54</td>
<td>0.22</td>
</tr>
<tr>
<td>BQ5: Synthesis Question</td>
<td>3.0</td>
<td>2.46</td>
<td>0.11</td>
</tr>
<tr>
<td>BQ6: Evaluation Question</td>
<td>2.38</td>
<td>2.92</td>
<td>0.04*</td>
</tr>
</tbody>
</table>

* indicates .05 or more significance
Higher of the two mean scores is highlighted in each question

Overall, the statistical analysis indicates that there is no significant difference between the two groups in the background knowledge of daylighting as measured by the IDL pre-test.

*Interior DayLighting quiz - IDL post-test: Comparison of group scores*

IDL post-test data was collected to determine the knowledge base of the students after the instructional intervention on daylighting. The mean scores of the IDL post-tests of both the groups differ by 0.5641 (L GRP:: \( M = 2.62, SD = 0.61 \); AL GRP:: \( M = 3.18, SD = 0.41 \)). An independent between-group t-test of the post-test variable, Aavg1_6 (\( p = .01 \)) indicate a statistically significant difference between the scores of the two groups of students (see Figure 4)
Figure 4. Frequency distribution of IDL overall post-test scores: Lecture group (n=13) and active learning group (n=13)

Similar to the IDL pre-test analysis discussed in the previous section, independent between-groups t-tests were conducted for each of the six (6) IDL post-test questions with each question addressing one of the 6 levels of cognitive thinking (AQ1 to AQ6) (Bloom, et al., 1956). An average of the convergent thinking questions of knowledge, comprehension, and application (Aavg1_3) and the average of the divergent thinking questions of analysis, synthesis, and evaluation (Aavg4_6) were similarly analyzed. Both the convergent and the divergent thinking questions mean scores (Aavg1_3 and Aavg4_6) show a significant difference between the two groups (p=0.04 and p=0.01 respectively). Thus it can be concluded that student performance in the convergent and divergent thinking question categories may be related to their instructional groups (see Table 4 for the group scores in the question categories and the corresponding statistical significance values).
<table>
<thead>
<tr>
<th>IDL Post-test - Question categories</th>
<th>Lecture</th>
<th>Active learning</th>
<th>P value : Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aavg1_3: Convergent Thinking</td>
<td>2.64</td>
<td>3.13</td>
<td>0.04</td>
</tr>
<tr>
<td>(Knowledge, comprehension &amp;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>application questions)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aavg4_6: Divergent Thinking</td>
<td>2.59</td>
<td>3.23</td>
<td>0.01</td>
</tr>
<tr>
<td>(Analysis, Synthesis &amp; Evaluation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>questions)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* indicates .05 or more significance
Higher of the two mean scores is highlighted in each question

Table 4. Mean scores for IDL post-test convergent & divergent thinking questions and $p$-value for difference between the two groups.

The mean scores of the IDL post-test evaluation comprehension level question, AQ2, and analysis level question, AQ4, differed between the groups by 1.08 and 0.85 respectively. An independent t-test of the pre-test variable, AQ2 ($p = .02$) and AQ4 ($p = .02$) indicates that this difference is statistically significant with the IDL post-test score mean of the AL group higher than the L group in these two questions. The knowledge level question, AQ1 with equal means ($p = .50$) appears to be the one least associated to the instructional intervention group. The AL group has a mean score higher that the L method group in all the other question levels, although the application (AQ3), synthesis (AQ5), and evaluation (AQ6) level questions do not show a statistically significant difference (see Table 5).

To summarize, the difference between the groups in questions AQ1, AQ3, AQ5, and AQ6 were not statistically significant. The statistically significant difference in the convergent and divergent thinking categories as seen in Table 4 might have been due to questions AQ2 and AQ4 (see Table 5) though this was not statistically tested for accountability.
<table>
<thead>
<tr>
<th>IDL: Post-test Questions</th>
<th>Lecture</th>
<th>Active Learning</th>
<th>( p ) value: Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>AQ1: Knowledge Question</td>
<td>3.69</td>
<td>3.69</td>
<td>0.50</td>
</tr>
<tr>
<td>AQ2: Comprehension Question</td>
<td>2.92</td>
<td>4.00</td>
<td>0.02*</td>
</tr>
<tr>
<td>AQ3: Application Question</td>
<td>1.31</td>
<td>1.69</td>
<td>0.21</td>
</tr>
<tr>
<td>AQ4: Analysis Question</td>
<td>2.38</td>
<td>3.23</td>
<td>0.02*</td>
</tr>
<tr>
<td>AQ5: Synthesis Question</td>
<td>3.08</td>
<td>3.46</td>
<td>0.19</td>
</tr>
<tr>
<td>AQ6: Evaluation Question</td>
<td>2.31</td>
<td>3.00</td>
<td>0.11</td>
</tr>
</tbody>
</table>

* indicates .05 or more significance
Higher of the two mean scores is highlighted in each question

Table 5. Mean scores for each group for each IDL post-test questions and \( p \)-value for difference between the two groups

*Interior DayLighting quiz - IDL pre- and post-test: Comparison of composite group scores*

The student performances in the IDL pre- and post-tests were analyzed individually above to assess the knowledge base of students before and after the instructional intervention. This section deals with a comparison of within-group performance between the pre- and post-tests.

When the composite group scores in the IDL pre- and post-tests are compared graphically (see Figures 5 -7), there is an overall increase in the performance for both groups in the post-tests after the instructional intervention. Convergent scores increased for both groups. Divergent scores increased for the AL group, but the L group shows a lower mean score in the post-test (see Figure 7). Figures 5, 6 and 7 graphically show the comparison of performance for the L and AL groups in the IDL pre- and post-tests.
Figure 5. IDL overall test score: Composite of Q1 to Q6 for pre- and post-test scores for lecture and active learning groups

Figure 6. IDL convergent thinking category score: Composite of Q1 to Q3 for pre- and post-test scores for lecture and active learning groups
The effect of the instructional intervention can be assumed to be determined using the base scores that are provided by the pre-test scores. Though the gain score of students in each question is important, a direct analysis of both the pre- and post-test scores gives a quick understanding of the group performances in the post-tests, after the instructional intervention.

A comparison of the collective group performance in each question level shows that the AL group has a relatively equal or higher performance in their IDL post-tests in all the question levels compared to the L group. The performance of the L group shows a reduced score in three post-tests scores: application (Q3), analysis (Q4) and synthesis (Q5) level questions. It should be noted that the L group had near equal scores to the AL group in the individual IDL pre-test questions.
A visual comparison of the two group performances indicate an overall improved performance of the AL group compared to the L group. Figures 8, 8a to 8f represents a comparison of pre- and post- test performance of L and AL groups in each of the IDL questions. These figures compare the performance of students before and after the instructional intervention using the mean scores for each of the cognitive level questions, Q1 to Q6. Figures 8a to 8c illustrate relative scores for convergent thinking knowledge, comprehension, and application questions; and Figures 8d to 8f illustrate the relative scores for the divergent thinking analysis, synthesis, and evaluation questions.
Figure 8. Comparison of pre- and post-test group performance for each IDL questions.

*Interior DayLighting quiz - IDL gain scores*

The within-group difference (diff) between the pre- and post-tests represents the mean gain scores which indicate the students' within-group performance between the tests. This comparison is further analyzed with respect to the instructional intervention groups. The difference scores are analyzed between the two instructional groups for overall test gain (Diff_all), the convergent (Diff_1_3) and divergent (Diff_4_6) thinking questions gains and also gains for each IDL question (Diff_Q1 to Diff_Q6).

*Gain Scores – IDL composite comparison.* The gain scores of the overall IDL tests of both groups differ by 0.47 (L GRP:: $M = 0.36$; AL GRP:: $M = 0.83$). An independent t-test of the variable, Diff_all ($p = .0550$) indicates there is a tendency toward a statistically significant difference between the gain scores of the two groups. Thus the IDL difference in mean gain scores of the two groups is almost significantly different (see Diff_all in Table 5 and Figure 9). The convergent thinking questions’ gain score, Diff_1_3 (knowledge, comprehension &
application level questions), shows no significant difference between the groups \((p=0.34)\) and the higher order divergent thinking questions’ gain score, Diff_4_6 (analysis, synthesis and evaluation level questions), shows significant difference between the two groups \((p=0.0045)\) as seen in Table 6 and Figure 9. Divergent thinking scores would appear to account for the almost significant difference in the gain scores of the overall IDL test scores.

<table>
<thead>
<tr>
<th></th>
<th>Lecture</th>
<th>Active learning</th>
<th>P value : Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diff_all: Aavg1_6 – Bavg1_6: Overall Test</td>
<td>0.36</td>
<td>0.83</td>
<td>0.0550</td>
</tr>
<tr>
<td>Diff_1_3: Aavg1_3 – Bavg1_3: Convergent Thinking (Knowledge, comprehension &amp; application)</td>
<td>0.90</td>
<td>1.08</td>
<td>0.34</td>
</tr>
<tr>
<td>Diff_4_6: Aavg4_6 – Bavg4_6: Divergent Thinking (Analysis, Synthesis &amp; Evaluation)</td>
<td>-0.18</td>
<td>0.59</td>
<td>0.0045*</td>
</tr>
</tbody>
</table>

* indicates .05 or more significance
Higher of the two mean scores is highlighted in each question

Table 6. Gain scores for IDL overall test, convergent & divergent thinking category questions and p-value for difference between the two groups.

Figure 9. IDL overall test, convergent (Q1 to Q3) and divergent (Q4 to Q6) gain scores comparison for lecture and active learning groups
Gain Scores – IDL - Each question. When looking at the individual questions, the AL group has higher gain scores for all question levels except Q2 (comprehension question). This is in contrast to smaller gain scores, apart from Q2, that the L group has, including negative gains for three questions: Q3 (Application level), Q4 (Analysis level), and Q6 (Evaluation level) (see Table 7 and Figure 10).

The gain scores of Q4 (Analysis) and Q5 (Synthesis) are the only two cognitive thinking questions that have a statistically significant difference between the two groups. An independent t-test analysis shows that the gain scores between the groups for questions Q4 and Q5 are significantly different ($p=0.02$ and $p=0.03$ respectively) as seen in Figure 10 and Table 6. The cognitive level questions, Q1 (Knowledge), Q2 (Comprehension), Q3 (Application) and Q6 (Evaluation) do not show a significant gain score difference between the groups.

<table>
<thead>
<tr>
<th>IDL: Pre-test Questions</th>
<th>Lecture</th>
<th>Active learning</th>
<th>P value : Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diff_Q1: (AQ1-BQ1) Knowledge level</td>
<td>0.92</td>
<td>0.92</td>
<td>0.5000</td>
</tr>
<tr>
<td>Diff_Q2: (AQ2-BQ2) Comprehension level</td>
<td>2.00</td>
<td>1.85</td>
<td>0.4320</td>
</tr>
<tr>
<td>Diff_Q3: (AQ3-BQ3) Application level</td>
<td>-0.23</td>
<td>0.46</td>
<td>0.1410</td>
</tr>
<tr>
<td>Diff_Q4: (AQ4-BQ4) Analysis level</td>
<td>-0.5385</td>
<td>0.69</td>
<td>0.0200*</td>
</tr>
<tr>
<td>Diff_Q5: (AQ5-BQ5) Synthesis level</td>
<td>0.08</td>
<td>1.00</td>
<td>0.0330*</td>
</tr>
<tr>
<td>Diff_Q6: (AQ6-BQ6) Evaluation level</td>
<td>-0.08</td>
<td>0.08</td>
<td>0.4060</td>
</tr>
</tbody>
</table>

* indicates .05 or more significance  
Higher of the two mean scores is highlighted in each question

Table 7. Gain scores for each group for each IDL post-test questions and $p$-value for difference between the two groups
Measurement 2: IDA– Interior Design Analysis exercise

Variables used in the IDA exercise analysis

- IDA_PRE_Ct - Interior Design Analysis Pre-test daylighting Count
- IDA_PRE_Th - Interior Design Analysis Pre-test daylighting Theory
- IDA_POST_Ct - Interior Design Analysis Post-test daylighting Count
- IDA_POST_Th - Interior Design Analysis Post-test daylighting Theory
- IDA_DiffCt - Interior Design Analysis Gain score (Diff) Daylighting Count
- IDA_DiffTh - Interior Design Analysis Gain score (Diff) Daylighting Theory

Inter-rater Reliability

Since the IDA exercises were evaluated by two evaluators, statistical analysis was conducted to establish inter-rater reliability. Table 8 shows the Cronbach’s alpha value above 0.90 for all the variables that represents the level of reliability between the two raters’ scores. In other words, when the scoring of the two raters is compared, they are matched 92 to 96% of the time, showing good inter-rater reliability.
Table 8. Cronbach’s Alpha - Inter-rater reliability test

<table>
<thead>
<tr>
<th>Number of items</th>
<th>Cronbach’s alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td>IDA_PRE_Ct</td>
<td>2</td>
</tr>
<tr>
<td>IDA_PRE_Th</td>
<td>2</td>
</tr>
<tr>
<td>IDA_POST_Ct</td>
<td>2</td>
</tr>
<tr>
<td>IDA_POST_Th</td>
<td>2</td>
</tr>
</tbody>
</table>

* indicates .90 or more reliability

Table 9. Mean scores for each group for daylight count and theory integration in IDA pre-test and p-value for difference between the two groups.

<table>
<thead>
<tr>
<th>IDA: Pre-test variables (N=25)</th>
<th>Group</th>
<th>Mean</th>
<th>P value : Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>IDA_PRE_Ct: Daylighting concept Count</td>
<td>Lecture (n=12)</td>
<td>1.21</td>
<td>0.41</td>
</tr>
<tr>
<td></td>
<td>Active Learning (n=13)</td>
<td>1.08</td>
<td></td>
</tr>
<tr>
<td>IDA_PRE_Th: Daylighting Concept theory</td>
<td>Lecture (n=12)</td>
<td>1.79</td>
<td>0.38</td>
</tr>
<tr>
<td></td>
<td>Active Learning (n=13)</td>
<td>1.58</td>
<td></td>
</tr>
</tbody>
</table>

* indicates .05 or more significance
Higher of the two mean scores is highlighted in each question

Interior Design Analysis exercise – IDA pre-test – base scores

Out of the forty one students (N=41) in the design studio course, twenty five students (12 L and 13 AL) provided usable data for the Interior Design Analysis (IDA) exercise (n=25). Attending the IDA pre- and post-tests as well as the instructional interventions were the main criteria in determining usable student data. The IDA pre-test scores for analysis include the two variables, daylighting count (IDA_PRE_Ct) and daylighting theory incorporation (IDA_PRE_Th). Independent t-test analysis of both the variables IDA_PRE_Ct (p = 0.41) and IDA_PRE_Th (p = 0.38) indicate no significant statistical difference between the performance of the A and AL instructional groups (see Table 9).
The performance of the students in the IDA post-test is better understood when compared to the IDA pre-test scores, in particular the gain scores. Figure 11 shows the pre- and post-test scores of both groups for both the IDA_PRE_Ct and IDA_PRE_Th.

![Figure 11. Mean scores comparison for each group for daylight count and theory integration in IDA pre- and post-tests](image)

From the analysis of the IDA pre-test scores it is inferred that there are no statistically significant differences in the scores between the groups. From this base score, the performance of the students in the IDA post-test is tested using independent t-test for the gain score variables IDA_DiffCt and IDA_DiffTh (see Table 10 and Figure 12 for the gain score comparison and the corresponding statistical significance).

Both the groups, L and AL, had negative gain scores except for the one positive gain score in the L group: IDA_DiffTh. The difference in gain scores between the two groups, L and AL, for both variables IDA_DiffCt ($p = 0.28$) and IDA_DiffTh ($p = 0.06$) is not statistically significant.
<table>
<thead>
<tr>
<th>IDA: Gain Score variables (n=25)</th>
<th>Group</th>
<th>Mean</th>
<th>P value : Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>IDA_DiffCt:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gain Score of Daylighting concept Count</td>
<td>Lecture (n=12)</td>
<td>-0.33</td>
<td>0.28</td>
</tr>
<tr>
<td></td>
<td>Active Learning(n=13)</td>
<td>-0.65</td>
<td></td>
</tr>
<tr>
<td><strong>IDA_DiffTh:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gain Score of Daylighting Concept theory</td>
<td>Lecture (n=12)</td>
<td>0.21</td>
<td>0.06</td>
</tr>
<tr>
<td></td>
<td>Active Learning(n=13)</td>
<td>-0.65</td>
<td></td>
</tr>
</tbody>
</table>

* indicates .05 or more significance
Higher of the two mean scores is highlighted in each question

Table 10. Gain scores for each group for daylight count and theory integration in IDA post-test and p-value for difference between the two groups

Figure 12. Gain scores comparison for each group for daylight count (IDA_DiffCt) and theory integration (IDA_DiffTh) in IDA post-test exercise

Measurement 3: DP– Design Project review

The daylighting module was administered to the students in IMSD IV. As part of the course, the students worked in teams or individually on a design project and the DP measurement analyzes the design projects for their use of daylighting principles. Out of 37
participants (N=37), 15 students provided usable data (n=15). As noted in Chapter 3, the criterion for including data was the student’s association with the instructional groups, L and AL. If the design project teams had a mix of students from both the L and AL groups, that group was excluded from this analysis.

The following abbreviations are used for the data analysis variables:

- DSN_DL_Ct: DayLighting concept in the Design—Student Count
- DSN_DL_R_Ct: DayLighting concept in the Design—Researcher Count
- DSN_DL_Th: DayLighting Theory/concept integration in the Design

The design project was analyzed for three (3) variables. The daylight count (DSN_DL_Ct and DSN_DL_R_Ct) is a number count representing the number of different ways in which daylight concepts were used in the student design project as determined by the researcher (see Chapter 3 for variable definition). The daylight integration variable (DSN_DL_Th) represents the level of integration of daylight concepts and theories in the student designs with a high score of 4 for very strong agreement on daylight concept integration and 0 for strong disagreement on daylight concept integration.

The mean scores for DSN_DL_Ct (p = 0.11) does not show a statistically significant difference between the two groups. DSN_DL_R_Ct (p = 0.17) also shows no significant relationship between the group association (see Table 11 for the DP variables comparison between L and AL along with the statistical significance values).
Table 11. Mean scores for each group for student daylight count, researcher daylight count and theory integration in DP and p-value for difference between the two groups

As part of the DP problem statement, the instructor of the course had asked students to list their environmental goals along with the final design project in IMSD IV. From a total of fifteen student participants (n=15), seven students mentioned daylight in writing in their DP presentation writing. Figure 13 shows the number count of expressions of daylight concepts as their design intent. In both groups, four student participants did not express any intent of using daylight. Three students in L and four students in AL expressed daylight concept use in their design.

Figures 13-15 show the student participant’s performance in the three DP variables, DSN_DL_Ct, DSN_DL_R_Ct, and DSN_DL_Th while Figure 16 examines the student group / team performance in the three variables.
Figure 13. Design Project: Daylight concept use count by student & number of students

The count of daylight use, DSN_DL_R_Ct might not be the deliberate intent of the designer – it could either be by chance or subconscious decision. Two students in the L group had their design projects comply with a few daylighting principles that they did not express explicitly in their environmental concerns goal. These were included in DSN_DL_R_Ct (see Figures 14).

Figure 14. Design Project: Daylight concept use count by researcher & number of students
Figure 15 shows the DSN_DL_Th variable, with score of four being in strong agreement with the integration of daylighting concepts. Students in the AL group have shown stronger level of integrating daylighting in their designs with four students having scores of two and above compared to two students in the L group (see Appendix J for the scaling rubric).

![Bar chart showing DSN_DL_Th: Daylight integration in Design](image)

**Figure 15. Design Project: Daylight theory integration scores & number of students**

While an independent t-test of the three variables (see Table 10) show no statistically significant difference in the performance of the two groups for the three analysis variables, a graphic frequency analysis as seen in Figure 16, show the performance of the student groups for each of these variables (see Appendix J). A combined graphical analysis of the three variables corresponding to the two groups, L and AL, and the design project team identification (DSN_ID) is shown in Figure 16. Design teams ID 1 to 6 are the AL student teams and 7 to 12 are the L student teams. Three AL teams, team three, four and five have integrated daylight design in their design project. As per Figure 16, compared to the L group they have a greater level of using the daylighting concepts. Though the difference between
the performances of the two instructional groups was not statistically significant, an analysis on the basis of conscious effort to integrate the daylighting concepts appears to show that the teams in the AL group performed better than the L group.

Figure 16. Mean scores Design Project evaluation based on student design teams
(DSN_IDs 1 to 6: Active Learning Teams and DSN_IDs 7 to 12: Lecture Teams)

A graphical analysis was conducted to see if the students with higher level cognitive thinking (divergent thinking) also demonstrated effectiveness in the application or integration of their learning to the design project (see Figures 17-19).
Figure 17. Mean scores of design teams comparing daylight concept use (DSN_DL.Ct) in Design Project with the divergent thinking IDL post-test score (Aavg4_6)

(AL Team 3 and L teams 11 and 12 are excluded from the graph due to non-availability of data for the Aavg4_6 variable)

Among the five AL teams that performed relatively well in the divergent thinking questions of the IDL Post-test, 2 teams had 9 instances of evident inclusion of daylighting concepts compared to the 1 L team out of 4 that had 3 instances of daylight inclusion.
Figure 18. Mean scores of design teams comparing daylight concept use (DSN_DL_R_Ct) in Design Project with the divergent thinking IDL post-test score (Aavg4_6)

(AL Team 3 and L teams 11 and 12 are excluded from the graph due to non-availability of data for the Aavg4_6 variable)

The only difference between Figure 17 and 18 is the DSN_DL_R_Ct of the L teams 7 and 8. The scoring of the AL teams remains the same as Figure 17, as DSN_DL_Ct and DSN_DL_R_Ct are identical.
Figure 19. Mean scores of design teams comparing daylight theory integration (DSN_DL_Th) in Design Project with the divergent thinking IDL post-test score (Aavg4_6)

(AL Team 3 and L teams 11 and 12 are excluded from the graph due to non-availability of data for the Aavg4_6 variable)

The level of integration of daylighting theory in the design project is above the average score of 2 for two AL design teams (4 and 5). Though the other AL teams have a above average score in their divergent thinking IDL post-test questions (Aavg4_6), they did
not translate this to the design project. Team 9 of the L group is the only team that has shown an average integration of daylight concepts.

**Measurement 4: SR– Student Reflection write-up**

The SR write-up was a two-minute reflection exercise on the daylighting session for the thirty four (n=34) students who attended either of the instructional intervention. The exercise was intended to tap the thoughts of students concerning the effectiveness of the instructional methods: Lecture and active learning. See Appendix L for the full text version of the student written response. The student identities are eliminated to preserve the identity of the participants.

**SR exercise was an open ended question, with students responding to “REFLECTION on DAYLIGHTING SESSION”. The reflection criteria were formulated after a qualitative analysis of the response contents. Table 12 summarizes the responses under the criteria terms. The following is the explanation for the table contents formulation:**

- **Criteria** - The factors discussed by students explicitly in the written response
- **Comments** - Lists some common comments given by the students within the listed criteria
- **Positive (P)** - Had positive thoughts about the criterion
- **Negative (N)** - Had negative thoughts about the criterion
- **General (G)** - Had general/ neutral/ unsure thoughts about the criterion

One point was assigned to the corresponding response type for each occurrence of the criterion.
<table>
<thead>
<tr>
<th>Criteria</th>
<th>Positive</th>
<th>Negative</th>
<th>General</th>
<th>Comments preview</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Class size/split up</td>
<td>8</td>
<td>3</td>
<td>4</td>
<td>P: Liked it; N: No difference; G: Curious as to why?</td>
</tr>
<tr>
<td>b. Interaction: students/teams</td>
<td>1</td>
<td>8</td>
<td>1</td>
<td>P: Liked it; N: Did not help; G:</td>
</tr>
<tr>
<td>c. Interaction: instructor/material</td>
<td>3</td>
<td></td>
<td></td>
<td>P: Good interaction; N: G:</td>
</tr>
<tr>
<td>d. Improved attentiveness</td>
<td>2</td>
<td>7</td>
<td></td>
<td>P: More attentive; N: G:</td>
</tr>
<tr>
<td>e. Interesting topic</td>
<td>2</td>
<td></td>
<td></td>
<td>P: Interesting subject; N: G:</td>
</tr>
<tr>
<td>f. Importance of topic</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>P: Important subject; N: G: Generally useful</td>
</tr>
<tr>
<td>g. Amount of information</td>
<td>3</td>
<td>4</td>
<td></td>
<td>P: Good content; N: G:</td>
</tr>
<tr>
<td>h. Clarity of subject covered</td>
<td>1</td>
<td></td>
<td></td>
<td>P: Confusing; N: G:</td>
</tr>
<tr>
<td>i. Student learning</td>
<td>6</td>
<td>2</td>
<td>2</td>
<td>P: Learnt a lot; N: Didn't learn; confusing; G: Glad I learnt it</td>
</tr>
<tr>
<td>j. Topic review</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>P: Good overview; N: G: very general</td>
</tr>
<tr>
<td>k. Method of instruction</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>P: Better way to teach; N: didn't gain by lecture; G: Same as any other</td>
</tr>
<tr>
<td>l. Schedule of topic in semester</td>
<td></td>
<td>1</td>
<td></td>
<td>P: N: Earlier in semester; G:</td>
</tr>
<tr>
<td>m. Time spent</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>P: Good; N: Spend more time; G: We should spend more time on it</td>
</tr>
<tr>
<td>n. Reduced number of sessions</td>
<td>1</td>
<td>1</td>
<td></td>
<td>P: Liked it; N: G:</td>
</tr>
<tr>
<td>o. Overall experience</td>
<td>1</td>
<td></td>
<td>3</td>
<td>P: Liked it; N: G: Like any other</td>
</tr>
</tbody>
</table>

Table 12. Text analysis of student reflection write-up

(see Appendix P for a full text version of the student reflection comments)
Review of table 12 and Appendix P shows that comments in order of their frequency of occurrence were on: class split into two groups (22), student learning (12), student interaction (10), attentiveness(9), amount of information (7) and method of instruction (6).

L group comments. Out of a total of 41 comments by the L group, 48% were positive, 21% were negative and 29% were general. The L group comments were split between liking and not liking the dividing up of the class for the daylighting session. This group had 72% of the total comments on the class size. Half the group felt that it was good to have a smaller class while the others did not find difference in the overall effect. Students felt it was like any other lecture and did not comment positively on student learning. But they had couple of positive comments on improved attentiveness (able to sit closer to the board) and interesting nature of the topic. They also liked the content/ amount of information included in the lecture.

AL group comments. Out of a total of 50 comments by the 17 AL students participating in the SR exercise, 74% were positive, 12% were negative and 14% were general. AL students in general, liked being in the smaller class group and had positive remarks on the interaction level in class (both among students and with the instructor). They also had some positive comments on student learning and increased attentiveness among students. Few negative comments were written by the AL students about the active learning strategy used in the daylighting module: One comment indicated that the interaction among students/teams ‘did not help’; two comments on student learning indicated that it was confusing and hard to ‘jump’ between activities.

Further discussion of the results in the context of the research questions and hypothesis, its implications, and the research methodology that might have contributed to the outcome will be detailed out in Chapter 5.
CHAPTER 5: DISCUSSION AND CONCLUSION

Overview

The purpose of this study was to compare the effectiveness of active learning in interior design with the conventional lecture format, using instruction in interior daylighting within the Interior Materials Systems and Details IV (IMSD IV) course as the vehicle. Four criteria were used as an operational means to test the research hypothesis, as explained in chapter 3. While the first two criteria for effectiveness were tested within IMSD IV, the third criterion was tested both within (IMSD-IV) and outside the course (Interior Design Studio IV – IDS IV) to analyze the possible transfer of information beyond course boundaries. The fourth criterion was the analysis of student comments on the instructional interventions. To summarize, the question that was addressed in the research was: Is active learning intervention more effective compared to a lecture in terms of understanding the subject, using it in the appropriate context of requirement, and the students’ impression on the learning experience?

In this chapter the research hypothesis as discussed in the methodology (Chapter 3) is tested against the results that were presented in chapter 4. The research hypothesis and the criteria or operational means of testing the hypothesis are also reviewed. Each criterion is discussed in the context of the results obtained from the four measurements including: Interior DayLighting (IDL) quiz, Interior Design Analysis (IDA) exercise, Design Project (DP) review and Student Reflection (SR). The chapter also links the results of the research to the larger context of student active learning in higher education and to other related research in the field.
This research studies the effect of active learning in an interior design daylighting session compared to the lecture method of instruction. As indicated in Chapter 3, the research was designed to test one hypothesis using four operational means. The students were divided into two instructional groups – Lecture (L) and Active Learning (AL). The randomly formed instructional groups were tested for similarity using the IDL pre-intervention quiz scores. The statistical comparison of the overall (Bavg1_6), convergent (Bavg1_3), and divergent (Bavg4_6) thinking questions’ scores of the IDL pre-test intervention quiz of the two instructional groups indicated no significant differences (p < .05). Hence it can be assumed that the knowledge base of the two groups of students as indicated from the tested variables was similar (see Figure 3 and Tables 2-3).

Statement of Hypothesis

Hypothesis 1: Effectiveness of instruction, lecture and active learning, in the daylighting module

H1: There is a significant difference in the effectiveness of instruction of the daylighting module between students involved in the AL method of instruction compared to students in the L method of instruction.

The test of the effectiveness of the instructional interventions was based on Bloom’s Taxonomy of cognitive thinking (Bloom, et al., 1956). To review, the following are the four criteria identified as the operational means for testing the hypothesis:

Criterion 1: (CR 1) Student knowledge, comprehension, and application of daylighting information, using the IDL quiz: quiz Questions Q1_3 (Q1 to Q3) and Diff_1_3 (The score difference between the pre- and post-tests for the average of Q1, Q2 & Q3)
Criterion 2: (CR 2)  
Student analysis, synthesis, and evaluation of daylighting information, 
using the IDL quiz: quiz Questions Q4_6 (Q4 to Q6) and Diff_4_6  
(The score difference between the pre- and post-tests for the average 
of Q4, Q5 & Q6)

Criterion 3: (CR 3)  
Student use of daylighting information in the appropriate context using 
two measures:  
a. IDA exercise – Outside course with: Daylight number count (Ct) 
and Daylight Theory application (Th)  
b. DP review – Within course with: Daylight student number count 
(DL_Ct), Daylight Researcher number count (DL_R_Ct), and Daylight 
Theory application (DL_Th)

Criterion 4: (CR 4)  
Student impression of the learning process using SR about the 
daylighting instructional interventions with written student comments 
categorized as positive (P), negative (N) and General (G) comments.

Discussion on these four operational means of testing the hypothesis is as follows:

CR 1: Student knowledge, comprehension, and application of daylighting information

Evidence of knowledge, comprehension, and application of daylighting information 
will show a statistically significant difference between students experiencing an 
active learning method of instruction compared to students in the lecture method.

The three cognitive thinking levels of knowledge, comprehension, and application of 
daylighting information constitute the convergent thinking questions. The three convergent
thinking question levels Q1, Q2 and Q3 of the pre- and post-tests of the IDL quizzes in IMSD IV addressed the following content on daylighting: (see Appendix E and G)

Q1: Knowledge: Sources of daylight and sun angles.
Q2: Comprehension: Interior shading device and solar angle at different latitudes
Q3: Application: Solar chart and daylight penetration in a building section

The variable used to analyze the convergent thinking ability of the instructional student groups is “Diff_1_3” and can be defined as follows:

\[ \text{Diff}_{x \_y} \] - Difference in pre & post test scores (Diff) in average of questions x to y

(Eg: Diff_1_3 include questions Q1, Q2 & Q3)

The variable Diff_1_3 was used to analyze the L and AL groups’ difference in performance between the pre- and post-tests for the convergent thinking questions. Based on the statistical analysis, the difference in mean gain scores of the instructional groups, L and AL (M = 0.90 and M = 1.08 respectively), is not statistically significant (p = .34) (see Table 6).

Even an analysis of the three individual questions, does not reveal a significant difference in the student performance. Except the gain score of L for Question 3 (Q3) of the IDL quiz, the other two gain scores for both the instructional groups are positive. Question 3 (Q3) which was designed at the application level of cognitive thinking, has a negative score for L indicating a lower performance in the post-test (see Figure 7 and Table 7; and Figure 8).
Overall, the results of the convergent thinking questions in the IDL quiz show no significant difference in the performance of students in the two different instructional groups, L and AL. Based on the Independent t-test analysis, the results of CR 1 failed to support the research hypothesis.

**CR 2: Student analysis, synthesis, and evaluation of daylighting information**

Evidence of analysis, synthesis, and evaluation of daylighting information will show a statistically significant difference between students experiencing an active learning method of instruction compared to students in the lecture intervention.

The three cognitive thinking levels of analysis, synthesis, and evaluation of daylighting information constitute the divergent thinking questions. The three divergent thinking question levels Q4, Q5 and Q6 of the pre- and post-tests of the IDL quizzes in IMSD IV addressed the following content on daylighting: (see Appendix E and G)

- **Q1: Analysis:** Interior surface reflection and daylighting
- **Q2: Synthesis:** Brightness contrast ratio and lighting spaces
- **Q3: Evaluation:** Integration of electric lighting with daylighting

The variable used to analyze the divergent thinking ability of the instructional student groups is “Diff_4_6” and can be defined as follows:

\[
\text{Diff}_{x,y} = \text{Difference in pre \& post test scores (Diff) in average of questions x to y}
\]

(Eg: Diff_4_6 include questions Q4, Q5 \& Q6)
The statistical analysis of the significance of the difference between the two groups for the variable Diff_4_6 exceeded the 0.05 significance level ($p = .0045$). Based on this analysis, the difference in mean gain scores of the instructional groups, L and AL ($M = -0.18$ and $M = 0.59$ respectively), is statistically significant (see Table 6).

An analysis of the three questions individually reveals significant group differences in the analysis (Q4) and synthesis (Q5) questions. While Question 5 (synthesis) has a positive gain score, Question 4 (analysis) and Question 6 (evaluation) have negative scores for the L group indicating lower performance in the post-test. AL had higher gain scores compared to the L group, all in the positive direction, indicating a higher improvement in performance in the IDL post-test (see Figure 7 and Table 7; Figure 8).

Overall, the results of the IDL quizzes, show a significant difference in the performance of students in the two different instructional groups in the divergent thinking questions. Based on the Independent t-test analysis, the results of CR 2 support the research hypothesis.

**CR 3: Student use of daylighting information in the appropriate context**

Evidence of ability to use daylighting information will show a statistically significant difference between students experiencing an active learning method of instruction compared to students in the lecture method.

Testing CR 3 can be done with an analysis of the results of the two measurements: IDA exercise, and DP review. The two measurements test two different scenarios of application: within a course context and outside the course context. The IDA exercise was
conducted in a different course, IDS IV, while the DP review was part of IMSD IV in which the instructional intervention occurred. The design project was a one time submission and does not have a pre-test for comparison. So the learning criterion of applying daylighting information in the appropriate context tested by CR 3 has two different evaluation scenarios:

a. Outside the course limits - IDA exercise, including both pre- and post-tests.

b. Within the course – DP review, using only a post design project

a. Outside the course limits. Testing CR 3 for outside course limits was based on the IDA exercise in IDS IV. Table 10 indicates an overall negative mean score for the gain score values in the IDA exercise for both groups with the exception of the use of theory or thoroughness of discussion of daylighting variable for the L group. It is the only variable that shows a positive gain in the IDA exercise. With an Independent t-test analysis, results do not show a significant difference between the performances of the L and AL instructional groups. The negative gain scores, indicating the absence of more count of daylighting concepts in particular, could have resulted from other extraneous factors such as the research methodology which will be discussed in detail later in the limitation section of this chapter. Based on this analysis, the results of the IDA exercise addressing CR 3 failed to support the research hypothesis.

b. Within the course. Testing CR 3 based on within course exercise using the DP, which was a culmination of IMSD IV. The mean scores of daylight number count of concept usage and integration in the projects were relatively high for the AL group compared to the L group (see Table 11). But this difference is not statistically significant. The scoring rubric indicates a score of 2 for a neutral position and a score of 3 or 4 for good level of integration of daylight concepts in the design (see Appendix J and Figure 13). Students in the AL group
had daylighting concepts well integrated within the design compared to the lecture group. The statistical significance for the count and theory integration is 0.10, which indicates a trend, but not statistically significant support of the hypothesis. Based on this analysis, the results of the DP review addressing CR 3 failed to support the research hypothesis.

**CR 4: Student impression on the learning process**

Evidence of impression on the learning process will show a statistically significant difference between students experiencing an active learning method of instruction compared to students in the lecture method.

The text analysis of the student reflection writing revealed experiential views of students who attended either one of the two instructional interventions (AL or L). Students in the L group made a total of 41 comments on the daylighting intervention with 20 being positive, 9 negative and 12 general. Out of a total of 50 comments from the AL group, 37 were positive, 6 were negative and 7 were general (see Table 12 and Appendix P).

The comments of the L group were more towards the class size and also questioning the need for splitting up the class. 16 of the 22 comments addressing this logistic issue were from students in L. Eight (8) of those 16 comments liked the smaller size of the class. This seems to indicate a strong curiosity of the students on the instructional procedure, which might have introduced an extraneous variable. A few L group students (number of student comments in parenthesis) also commented positively on the importance and interesting nature of the topic (2), increased attentiveness (2) and quantity of information covered during the instructional session (2) (see Table 12 & Appendix P).
The AL student comments were concentrated on the interaction level in the class, both among students and with the instructor. Overall, 24 of the 37 positive comments by the AL students were about interaction among students and with faculty (11), improved attentiveness (7), and positive student learning experience (6).

The various criteria addressed by the two groups of students indicate that the AL students had a more positive overall learning experience when compared to the students in L. Based on a content text analysis, the results of SR measurement, addressing CR 4 qualitatively supports the research hypothesis.

Implications
Implications of this research study will address the findings from literature review, while the focus of discussion will be on two issues: the research design and the research findings.

Research design

*Research documentation to assess critical thinking measures.* Questions are very important for practice compared to theory and there is a need for high-quality, well-developed, well researched cooperative curricula in many subjects and grade levels (Slavin, 1995). Most cognitive research measures report grades, exam scores, and testing procedures with little documentation of whether or how these measures are assessing critical thinking (Cooper & Robinson, 1998). This thesis research compared the effectiveness of an active learning intervention with the lecture intervention, partly based on the students’ cognitive thinking levels (The questions used in the daylighting quizzes were based on Bloom’s Taxonomy of cognitive thinking (Bloom, et al., 1956)).
Research documentation to reveal actual materials used in research. Most cooperative learning models typically provide guidance to incorporate cooperative learning strategies in the class and do not provide actual materials. There is a need for development and research where cooperative learning and curriculum intersect (Slavin, 1995) The cognitive thinking level questions used and documented in the thesis may suggest a move towards expanding the research methodology and research conduct to a more open source code format wherein all the instructional modules and guidelines as well as the questions used for testing are revealed to inform future research.

Time factor in instructional intervention design. A common critique of active learning instructional interventions as indicated by Bonwell & Eison (1991) is its inherent tendency to take more time than a lecture intervention to cover the same content. The research revealed a relatively positive result and the minimal effort needed to convert the lecture to an active learning session. This might encourage a possible shift of future lecture session designs to incorporate an active learning format.

Research Findings

The findings from this study reveal that the active learning instructional intervention increased the performance of students in the higher order cognitive thinking domain of the divergent questions (analysis, synthesis, and evaluation) compared to the students in the conventional lecture method of instruction. This may imply that while higher order thinking questions need a more learner-centered approach, the convergent thinking questions of knowledge, comprehension and application can be equally efficient with both lecture and active learning instructional methods.
The research failed to establish a strong relationship between the instructional intervention method and the performance of students in a different course context. This may be due to the lack of individual motivation to perform in the analysis exercises. This result is further discussed and reasoned out in the limitations section.

The research also found that students who exhibited integration of daylighting in their design projects in AL were relatively more efficient in doing so compared to the students in the L group. The AL students also expressed more liking for the learning experience in the daylighting session than L students. Similar to the findings of Faust (as cited in Faust & Paulson, 1998) that showed 25% of students commenting on student interaction as a positive aspect of cooperative learning, students in AL had several positive comments including interaction level and student attentiveness in class. The thesis results imply that there could be a significant relation between instructional methods and the overall positive experience of the students. This further suggests that instructors can incorporate active learning methods in their instruction for a positive student learning experience.

There are inherent limitations in the deciphering of implications of the research based on the data analysis due to the scope and design of the study. This aspect of the research is discussed in detail in the following section.

Limitations

Interpretation of the result of this study may be affected by a number of factors that could not be controlled in the design of the study or during the data collection. First, the number of participants in the research was limited to the thirty-seven students in the course. This is a relatively small number for statistical analysis of data, especially when dividing the
group into two subgroups. Research studies like Paulson and Faust (Faust & Paulson, 1998), and most others conduct research for a longer time frame and for a larger participant group. Apart from the student number, due to time limitations in the course, the data collected from the IDL quizzes had only one question in each of the six cognitive thinking levels in the pre- and post- tests. A bigger class and more test questions in each cognitive thinking level would have provided more robust degrees of freedom in the data analysis.

Another limitation to the study resulted from the timing and schedule of the research. Due to unforeseen delay in the research schedule, the post-intervention IDA exercise was conducted in the final exam week of the semester and may not have received its due attention from the students. While the students took the pre-intervention IDA exercise sincerely with the same apparent diligence as any other graded quiz in a course, most of the students spent only one fourth of the allotted time to complete the post-intervention IDA exercise. The IDA post-intervention data revealed this practical problem of scheduling the research. Apart from the scheduling of the exercise, the use of the same image for both the pre- and post-intervention IDA exercise might have influenced the student response to this research exercise. Hence the use of criterion 3 for ‘outside course’ as a measurement level for testing the hypothesis proved to be ineffective in the research design.

The two instructional interventions were conducted by the instructor of the course to collect authentic responses from the students for the research quizzes. The active learning strategies and the entire course interventions were designed by the researcher for the instructor’s use. It is to be noted that the instructor is also a design studio instructor in the program. There was no way to assess the impact of the inherent variations in the instructor’s
active learning and lecture delivery styles in this research design. This is a potential intervening variable that was not controlled or assessed.

The research was conducted partly with the direct involvement of the researcher (e.g., IDA exercise - evaluation of a space) and partly the researcher worked behind the scene (e.g., developing IDL quizzes and the daylighting instructional interventions). If conducted with a more consistent approach with total exclusion of the researcher in the process of interacting with the students and the regular course requirements, the research may give more realistic research result.

The difference in the IDL quiz questions for the pre- and post-tests also need to be closely examined for their influence on the test results. Though efforts were made to balance the cognitive thinking levels in the pre- and post-tests, the complexity of questions might have influenced the results.

Additionally, content analysis of the IDA exercise was conducted by two faculty members, but the content analysis of DP in IMSD IV was completed by the researcher. While the student instructional group assignment was not known to the researcher at the time of the analysis, this analysis may have introduced a bias.

Some of the research participants were also involved in the 'Emerging Green Builders' group in Iowa State University that had frequent guest lectures on green design topics. The research did not accommodate the effects of this possible intervening variable in its design. It was not known which participants in the research were actively involved with this group.
Recommendation for future research

Based on the research process, the subsequent results, and an understanding of the limitations of the study, the following recommendations are listed for future research to refine the research.

**Number of research subjects (N).** Interior design classes have 40 students on an average. To avoid the lack of sufficient data future research efforts could conduct and compare the results of two instructional interventions, lecture and active learning, for the whole class. Different topics within the same subject (daylighting) could be used for the instructional interventions.

**Number of test questions.** Future research can include more questions in each of the cognitive thinking levels of knowledge, comprehension, application, analysis, synthesis, and evaluation. This would help generate more data for analysis and hence a more consistent way of determining performance levels, instead of relying on one question in each cognitive level of thinking.

**Researcher involvement.** Instead of the researcher being partially involved in the research, future research could follow a more consistent approach in one of the following two ways:

- The total elimination of the researcher from direct interaction with the research subjects. The instructor conducts the research tests as part of critical exams within the concerned courses.
- The researcher is involved directly with the entire research process and conducts the instructional interventions while the research tests are part of the course
requirement. But there is a high possibility of having researcher bias in such research methodology and it has to be taken into consideration.

*Active learning strategies.* The predominant active learning strategy used in the research was cooperative learning or learning in groups/teams. Future research could compare the use of an active learning technique for individual students with the cooperative learning technique in teams.

*Student learning styles.* The learning style of students and the teaching style of instructors vary for different individuals. When students are assigned to different groups of instruction methods, it may be ideal to group students based on test results of their learning styles. This would help to get a balanced team comprising of students with different learning styles. Then, with a larger number of research subjects, student performance in the tests can be analyzed based on their individual learning styles.

*Research schedule and timing of the tests.* Retention of design concepts for a long time is important for a life long learning experience. The instructional intervention may occur for more than two hours to reinforce the learning. Additional post tests could be conducted after a long interval and relate it to the instructional intervention, to study the students’ ability to retain the learned concepts.

**Summary and Conclusion**

The research started with the core question of should active learning replace conventional lectures in a design curriculum to enhance the learning effectiveness and experience of students? Though researches have been conducted on using active learning
strategies, the issues of covering subject content and time factor were not addressed as crucial constants. The amount of information covered and the time it needed were compromised to a more in depth understanding for students in an active learning strategy.

To establish a common criterion and an easier shift between the methods, this thesis research design accommodated the factors of ‘time’ and ‘content’ as constants for both the instructional methods.

The thesis studied the effectiveness of an active learning instructional method compared to a lecture method in a daylighting module within the Interior Materials Systems and Details IV (IMSD IV) course. The effectiveness of the instructional method was analyzed based on the following criteria: Six levels of cognitive thinking; use of information learnt within and outside the context of the course and the general impression of students on their learning experience.

Results of the Interior DayLighting (IDL) quizzes revealed a relatively better performance by the Active Learning (AL) group compared to the Lecture (L) group, in all the quiz questions, except the comprehension level question (Q2) were the performance of both groups were equal. The difference in group performance was significant in the analysis (Q4) and synthesis (Q5) questions. Overall the divergent thinking analysis, synthesis, and evaluation questions showed a significant difference in the gain scores for the two instructional methods with students in AL outperforming the students in the L group.

The IDA exercise, which was used as the criteria to evaluate the use of information outside the course context, failed to create useful data due to the unexpected change in the schedule of the test. The lack of serious participation from the students resulted in a data
that was not significant. The DP review showed that the AL students integrated daylighting design concepts into their design projects relatively more strongly than the L group. The Student Reflection (SR) write-up was conducted as the last activity in the research. The active learning students predominantly had positive comments. They repeatedly commented on increased attentiveness, interaction level in class and the general student learning experience. The lecture group was more inquisitive and interested in the smaller class size.

In conclusion, the active learning instructional module appears to have been effective in creating higher order thinking (at least for the short term) among the students. Though the research failed to establish a significant relationship between instructional method and information transfer across course contexts; it could serve as a suggestion for future research to test the transfer of information across courses. Even within the course, in the final design project AL students seem to be relatively more effective in integrating the daylight design theories and concepts within their designs than the L students. The research also revealed attitude difference between the two groups as well as the positive reactions to the daylighting instructional intervention by the AL students.

Finally, the research shows that though certain issues in incorporating active learning in conventional lectures were addressed in this study, more refinements need to be done to improve this model for future research in this subject. For this limited sample, the active learning instructional intervention showed some, albeit limited, increased evidence of student learning compared to the lecture method of instruction. This means that active learning could potentially replace conventional teacher-centered lectures in design non-studio courses for more effective student learning.
APPENDIX A. HUMAN SUBJECTS APPROVAL
DATE:       March 17, 2006
TO:         Geethapriya Balasubramanian
FROM:       Dianne Anderson, IRB Co-Chair
RE:         IRB ID # 06-134
STUDY REVIEW DATE: March 16, 2006

The Institutional Review Board has reviewed the project, “The effect of active learning in an interior design daylighting module” requirements of the human subject protections regulations as described in 45 CFR 46.101(b)(2). The applicable exemption category is provided below for your information. Please note that you must submit all research involving human participants for review by the IRB. Only the IRB may make the determination of exemption, even if you conduct a study in the future that is exactly like this study.

The IRB determination of exemption means that this project does not need to meet the requirements from the Department of Health and Human Service (DHHS) regulations for the protection of human subjects, unless required by the IRB. We do, however, urge you to protect the rights of your participants in the same ways that you would if your project was required to follow the regulations. This includes providing relevant information about the research to the participants.

Because your project is exempt, you do not need to submit an application for continuing review. However, you must carry out the research as proposed in the IRB application, including obtaining and documenting (signed) informed consent if you have stated in your application that you will do so or required by the IRB.

Any modification of this research must be submitted to the IRB on a Continuation and/or Modification form, prior to making any changes, to determine if the project still meets the Federal criteria for exemption. If it is determined that exemption is no longer warranted, then an IRB proposal will need to be submitted and approved before proceeding with data collection.

c:  Art & Design
Dorothy Fowles
File

ORC 04-21-04
Applicable exemption category(s):

(1) Research conducted in established or commonly accepted educational settings, involving normal educational practices, such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

(2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation.

(3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) Federal statute(s) require(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.

(4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available or if the information is recorded by the investigator in such a manner that subjects cannot be identified, directly or through identifiers linked to the subjects.

(5) Research and demonstration projects which are conducted by or subject to the approval of Department or Agency heads, and which are designed to study, evaluate, or otherwise examine: (i) Public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.

(6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the Food and Drug Administration or approved by the Environmental Protection Agency or the Food Safety and Inspection Service of the U.S. Department of Agriculture.
APPENDIX B. INTERIOR DESIGN ANALYSIS EXERCISE (IDA)
INTERIOR DESIGN ANALYSIS

Identify and discuss the design concepts incorporated in the space shown below.

Write the "KEYWORDS" and also briefly "DISCUSS/CRTIQUE/ANALYZE" each keyword.

DURATION: 15 Minutes

<table>
<thead>
<tr>
<th>Keyword</th>
<th>Discuss</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Thank You!
APPENDIX C. INTERIOR DESIGN ANALYSIS EXERCISE (IDA) HANDOUT
APPENDIX D. INTERIOR DESIGN ANALYSIS EXERCISE (IDA) EVALUATION FORM
INTERIOR DESIGN ANALYSIS - EVALUATION

Name of evaluator: ____________________ Date: ____________________

Student R-ID: ____________

1. Number of occurrences of daylighting concept.
   Correct: ______
   Incorrect: ______

   Total Num. Count: ______

   Note: The number of occurrences includes mentioning daylighting as a separate design concept or in relation to another design concept. If the same idea is repeated, count it as one occurrence only.

2. Thoroughness of “daylight” discussion is evident
   Score: ______

Scoring Rubric:

<table>
<thead>
<tr>
<th>Strongly disagree</th>
<th>disagree</th>
<th>Neutral</th>
<th>agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>
APPENDIX E. PRE-TEST: INTERIOR DAYLIGHTING QUIZ (IDL)
1. Identify two other primary sources of daylight apart from direct 'Sunlight' (Circle the appropriate letter options)
   a. Window
   b. Skylight (i.e., Clear or cloudy sky)
   c. Body of water
   d. Surface Reflection
   e. Clearstory

2. Assume a wall facing EAST, which of the two following blinds would serve well as an interior daylight control device? (Circle the appropriate letter option) And explain WHY below.
   a. Horizontal Blinds
   b. Vertical Blinds
3. Mark the 'direct solar radiation' at noon in August. Mark in ft. how deep the direct sun rays comes into the space. **Indicate the angle** used as degrees. Eg., 22 deg. (Get the sun angles from the following 'Sun Path Diagram'. Use protractor for drawing angles.)
4. Assuming you are looking through the window into the room, pick one scheme that would be ‘LEAST’ preferred for an effective day lit interior. (Circle the appropriate letter option)

(Note: The shaded surface indicates a very low reflectance percentage)

a. Floor  

b. Side wall  

c. Ceiling  

d. Back wall

Surface Characteristics that affect reflectance property of the shaded surface:

1.

2.

5. The following lighting scheme with two luminaries was designed for a computer station.

i. Explain the rationale behind this scheme.

ii. How would you translate the concept for use in day lighting a room?

(Not the exact lighting arrangement but the concept that it is addressing)

Source: 5th & 6th Grade Art Projects by J.
6. Evaluate the following conceptual integrated day and electric lighting and control plan options for their potential energy efficiency. (Circle the appropriate letter option)

Your evaluation includes: Justification of your choice and the rationale for eliminating the other options.

a. [Diagram]

b. [Diagram]

c. [Diagram]

d. [Diagram]
ArtID 353 Systems IV – S 06
ENVIRONMENTAL SYSTEMS FACTORS: DAYLIGHTING

PRE-TEST EVALUATION (Pre-Test Conducted on __________)

Name of evaluator: ______________ Date: ___________

Scoring Rubric:

<table>
<thead>
<tr>
<th>Incorrect</th>
<th>Partly correct/Partly Incorrect</th>
<th>Correct</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

Student R-ID: _____

<table>
<thead>
<tr>
<th>Question</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q 1. Daylight Sources</td>
<td></td>
</tr>
<tr>
<td>Q 2. Blinds – East Wall</td>
<td></td>
</tr>
<tr>
<td>Q 3. Marking Section &amp; Plan</td>
<td></td>
</tr>
<tr>
<td>Q 4. Interior Surface Reflectance</td>
<td></td>
</tr>
<tr>
<td>Q 5. Computer Station</td>
<td></td>
</tr>
<tr>
<td>Q 6. Evaluate the options</td>
<td></td>
</tr>
</tbody>
</table>

Total Pre-Test Score: _____ / 24

R-ID: _____

Average Pre-Test Score: _____ / 4

(Rounded off to two decimal spaces)

Average Q1 & Q2 Pre-Test Score: _____ / 4

Average Q3, Q4, Q5 & Q6 Pre-Test Score: _____ / 4
APPENDIX G. POST-TEST: INTERIOR DAYLIGHTING QUIZ (IDL)
Name: 

1. What two variables will you use to read the sun angles from the solar chart of a particular location?
   a. Orientation of the site
   b. Date of the year.
   c. Position & heights of windows
   d. Proportion of the room (Room height and depth)
   e. Time of the day

2. If you were asked to use day lighting principles for an interior design project in Australia, which exterior wall surface you think will receive ample direct sun light? (Circle the appropriate letter option)

   Explain WHY?
   a. South    b. East    c. North    d. West
3. Use your knowledge of day lighting design to explain the performance & the rationale of the following South facade building section in the City of Chicago, IL at noon on June 21 and December 21. 
(Use the Sun angle table for reference.)

(Mark the sun light path for June 21 & December 21 on the section)
4. Discuss the relationship between "interior surface reflectance" and "daylight design"?

5. Identify the shortcomings, if any, of this interior design in the context of daylight performance. Propose a scheme to overcome the problem(s) identified.
6. Evaluate the following conceptual integrated day and electric lighting options for their performance characters. (Circle the appropriate letter option)

Your evaluation includes: Justification of your choice and the rationale for eliminating the other options.

a. b.
APPENDIX H. POST-TEST EVALUATION: INTERIOR DAYLIGHTING QUIZ (IDL)
ArtID 353 Systems IV – S 06
ENVIRONMENTAL SYSTEMS FACTORS: DAYLIGHTING

POST-TEST EVALUATION (Post-Test Conducted on _________)

Name of evaluator: __________________________ Date: ___________

Scoring Rubric:

<table>
<thead>
<tr>
<th>Incorrect</th>
<th>Partly correct/Partly incorrect</th>
<th>Correct</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

Student R-ID: ______

<table>
<thead>
<tr>
<th>Q 1. Variables in Solar Chart</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q 2. Daylight in Australia – Solar wall</td>
<td></td>
</tr>
<tr>
<td>Q 3. Explain Section</td>
<td></td>
</tr>
<tr>
<td>Q 4. Interior Surface Reflectance</td>
<td></td>
</tr>
<tr>
<td>Q 5. Computer against a window</td>
<td></td>
</tr>
<tr>
<td>Q 6. Evaluate the options</td>
<td></td>
</tr>
</tbody>
</table>

Total Pre-Test Score: ______ / 24

R-ID: ______

Average Post-Test Score: ______ / 4
(Rounded off to two decimal spaces)

Average Q1 & Q2 Post-Test Score: ______ / 4

Average Q3, Q4, Q5 & Q6 Post-Test Score: ______ / 4
APPENDIX J. DESIGN PROJECT (DP) EVALUATION
INTERIOR DESIGN PROJECT - EVALUATION

Name of evaluator: ____________________ Date: ____________

Student R-ID: ______

1. Number of occurrences of daylighting concept.
   Total Num. Count: ______

   Note: The number of occurrences includes mentioning daylighting as a separate design concept or in relation to another design concept. If the same idea is repeated, count it as one occurrence only.

2. “Daylighting” is well integrated in the design solution.

   Score: ______

Scoring Rubric:

Strongly disagree | disagree | Neutral | agree | Strongly agree

0 | 1 | 2 | 3 | 4
APPENDIX K. STUDENT REFLECTION (SR) HANDOUT
Name: ___________________ Session Date: ______ 18th APR (Tuesday) ______ 20th APR (Thursday)

REFLECTION on DAYLIGHTING SESSION: ........Comments.......
APPENDIX L. LECTURE: DAYLIGHT MODULE
ENVIRONMENTAL FACTORS

DAYLIGHTING in Interior Design

OBJECTIVES: DAY LIGHTING SESSION

1. Importance of day light – What? & Why?
2. Sources of day light - From where?
3. Availability of day light - How much?
4. Day light distribution & Interiors
5. Day light integration with other building systems
6. Day light performance issues

JUSTIFICATION: DAY LIGHTING

1950's : Superior visual conditions
1970's : Energy crunch ... Possible energy savings
Now : Tangible and Intangible benefits

- Aesthetic - Play of light & shadows, CRI-Color Rendering Index
- Variety of spatial quality – Sun movement
- Psychological
  - Sense of well-being – natural light
  - Sense of orientation – link to exterior
  - Health related
  - Energy / Cost associated

JUSTIFICATION: Physiological benefits:

Full Spectrum Lighting:

FOR: Essential for human health & performance
- Skin health; dilates capillaries of the skin
- Vitamin D production in the body
- Destroys germs
- Stimulates energetic activity; reduces fatigue
- Feeling of well being; increases work output

AGAINST: Over exposure to UV
- Skin cancer; wrinkles
- Possible eye damage
- Degradation & fading of interior materials

JUSTIFICATION: Physiological benefits:

Full Spectrum Lighting: .... UV ....

FOR: Essential for human health & performance

AGAINST: Over exposure to UV
JUSTIFICATION: Psychological benefits:

SUNSHINE:
Direct sunshine in proper location & quantity
- stimulating & desirable
- avoid destroying visual acuity

VIEW:
Daylight not always ‘window with a view’
Window–Daylight–View... Can go together
Broad horizontal windows
more satisfying than narrow vertical ones
Optimum size: 20-30% of exterior window wall

JUSTIFICATION: Physiological benefits:

Sense of orientation:
Human need for relation to the outside environment
Being visually separated for long periods can be counter-productive.
- 'Feeling of insecurity'
- Ability to escape during emergencies
- 'Weather disorientation'
  loss of bodily time – circadian rhythms
SAD – Seasonal Affective Disorder

JUSTIFICATION: Psychological benefits:

BRIGHTNESS GRADIENTS & COLOR CONSTANCY:
Daylight – standard against which human mind measures all things seen
- Colors appear real and appropriate

CRI: 100
(Color Rendering Index)

JUSTIFICATION: Psychological benefits:

SUNSHINE:
Direct sunshine in proper location & quantity
- stimulating & desirable
- avoid destroying visual acuity

VIEW:
Daylight not always ‘window with a view’
Window–Daylight–View... Can go together
Broad horizontal windows
more satisfying than narrow vertical ones
Optimum size: 20-30% of exterior window wall

JUSTIFICATION: Physiological benefits:

Sense of orientation:
Human need for relation to the outside environment
Being visually separated for long periods can be counter-productive.
- 'Feeling of insecurity'
- Ability to escape during emergencies
- 'Weather disorientation'
  loss of bodily time – circadian rhythms
SAD – Seasonal Affective Disorder

THINGS TO CONSIDER IN LIGHTING DESIGN

Quantity - Quality - Energy

... for people to see what they want to see
(general or task specific)
fc (footcandles) on surfaces
(IESNA standards)
... for aesthetic satisfaction – designer & viewer
Characteristics: visual interest
  contrast & glare
JUSTIFICATION: Energy / Cost benefits:

Energy consumption:
- Electric Light Integration
  - Energy used
  - Heat output
- HVAC integration - Heating / Cooling Loads

Caution:
- Heat gain & Loss through windows/skylights
  IR heat component should be excluded from the bldg.
- Spectrally selective low-emissivity glazing
- Low U-value glazing assemblies

JUSTIFICATION: Energy / Cost benefits:

- Life-Cycle Cost
- Operation/Maintenance Cost

DAYLIGHTING OF BUILDINGS: Specific goals

- Get daylight in all feasible areas in significant, useful quantities (Per required IESNA Handbook)
- Distribute the daylight reasonably uniformly through all floor areas, with no significant dark spots
- Avoid allowing direct sunshine into the building interior that causes visual discomfort (brightness differences) or disability (glare)
- Provide controls for the electric lighting so that it will be diminished or eliminated when not needed

DAYLIGHT - From where? - SOURCES!

SKYLIGHT
- Sunlight scattered - Produces SKY LUMINANCE

SKY CATEGORIES - Clear - Partly Cloudy - Overcast
- Cloud cover: 0-20% - 20-70% - 70-100%
- Interior day light levels not high with clear skies!

SURFACE REFLECTION
- Site Features to consider:
  - Location of building on site - to bring in max. daylight
  - Adjacent buildings & surfaces - Grass-Concrete pavement-Snow
  - Trees & Shrub - Gives shade & reduces sky glare from interior
SUNLIGHT - How much? - AVAILABILITY in nature

Factors:
- PLACE 42 N
- DATE Apr 4
- TIME 2:30pm / 3:30pm

SERI - Solar Energy Research Institute
Daylight Data: Based on Location, month, day, time
Sun angles:
- Altitude angle
- Azimuth angle

LOCATION!!!
SITE & ORIENTATION

Orientation – Wall surfaces:
- Amount & type of daylight available for each wall surface varies
- Intensity of daylight varies depending on the location
42 N – Ames
South... East... West... North
(i.e., The south face of a building in Ames receives maximum direct sunlight)

SITE & ORIENTATION: 42 N

Openings to East & West: Low Sun angle
Horizontal or VERTICAL? controls
- The changing altitude angle of the sun in the morning doesn’t affect vertical controls compared to horizontal controls

Openings to South:
- Ample direct sunlight; needs sun control – Heat gain/loss
Openings to North:
- Ample indirect sunlight; needs sun control

INTERIOR SURFACE REFLECTION

FACTORS:
- Surface quality
  - Color
  - Texture
- Surface orientation
  - Angles of Surfaces
- Space proportion
  - Room Height

Specular surface
- Smooth, highly polished
- Angle of Incidence = Angle of Reflection
- Sharp contrast between adjacent surfaces

Surface quality – Texture
INTERIOR SURFACE REFLECTANCE

Matte surface
- Rough
- Light reflected in all directions
- No Bright spots
- Even/wise distribution of light

Reflectance of Colors

<table>
<thead>
<tr>
<th>Color</th>
<th>Reflectance</th>
</tr>
</thead>
<tbody>
<tr>
<td>white</td>
<td>80-85%</td>
</tr>
<tr>
<td>pale yellow / rose</td>
<td>80%</td>
</tr>
<tr>
<td>pale beige / lilac</td>
<td>70%</td>
</tr>
<tr>
<td>pale blue / green</td>
<td>70-75%</td>
</tr>
<tr>
<td>light gray</td>
<td>45-70%</td>
</tr>
<tr>
<td>pink</td>
<td>50-70%</td>
</tr>
<tr>
<td>tan</td>
<td>30-50%</td>
</tr>
<tr>
<td>red</td>
<td>20-40%</td>
</tr>
<tr>
<td>medium brown</td>
<td>25%</td>
</tr>
<tr>
<td>medium blue / green</td>
<td>20-30%</td>
</tr>
<tr>
<td>dark grey</td>
<td>20-25%</td>
</tr>
<tr>
<td>black</td>
<td>10%</td>
</tr>
</tbody>
</table>
INTEGRATION OF DAY & ELECTRIC LIGHTING

DAYLIGHT CONTRIBUTION IN THE SPACE
- Evaluating daylight 'illuminance levels' and contours
- Daylight zones
- 'Temporal variations' in daylight availability
  - direction and intensity
- Daylight distribution changes with adjustable shading and fenestration elements
INTEGRATION OF DAY & ELECTRIC LIGHTING

Two approaches to electric light design
- Designed to contrast with daylight – Atrium
- Designed to work together in a task/ambient approach
  - Ambient electric lighting
    - designed to reduce day light gradients
    - to balance luminance in the space
    - circuited and zoned to follow day light zones
      (aligning electric light circuit parallel to day light contours)
    - lights same surfaces as day light for smoother transition

DAYLIGHT - CONTROLS
(Fenestration & Lighting)

- Static Controls - Fixed & Manual
  - Overhangs
  - Louvers & Fins
  - Light shelf
  - Glazing
  - Interior controls
- Dynamic Controls - Automated

DAYLIGHT - CONTROLS
(Fenestration & Lighting)

LIGHTING CONTROLS - Types of photo sensor systems
1. Interior Open Loop: Day light considered
   - looks out to sense incoming light
   - remote location: away from task
   - can control many luminaires

2. Interior Closed Loop: Day & electric light considered
   - looks into space: towards task
   - can only control small number of luminaires
   - No direct light on the sensor
   - electronic dimming ballast
   - electric levels adjusted to req. light level
   - effective energy saver
QUALITY OF LIGHTING DESIGN!

- Contrast
- Glare

QUALITY of LIGHT: Contrast & Glare

CONTRAST is needed for good visual perception
Caused by: luminous/brightness differences
Depends on: illuminance (fc) on task, reflectivity of task

Hence to establish contrast there needs to be sufficient illuminance / light first...
Excessive contrast - impedes good visual response

QUALITY of LIGHT: Contrast & Glare

CONTRAST gone BAD! - GLARE!
Excessive contrast - impedes good visual response
Too much of light / reflected light in the field of view
Examples:
- On coming auto headlight in the dark of night
  - prevents view of dark roadway
- Ceiling mounted luminaires in direct view of user
  - prevents person's ability to see task.

QUALITY of LIGHT: Contrast & Glare

VEILING REFLECTION! (VR)
Results in loss of contrast.

Definition - Reflection of light from specular surfaces that reduce contrast and diminish visual performance

BRIGHTNESS CONTRAST

Transient adaptation limits
1 : 3 : 10
Task : Near : Far

Figure 2c. Visual angle of visual view, for near compared to far view.
CONTRAST & GLARE

DAYLIGHTING IN USE

- Light color - High reflectance
- Borrowed light from closed office - high glazing
- The Red partition wall acts like a light shelf and helps distribute light deep into the open office
- Open office plan with low partitions distribute daylight better
- Minimal electric lighting as needed

DEALING WITH DAY LIGHTING

- INTEGRATE – Think design as a whole
- BE RESPONSIBLE – Respond to the context
- OBSERVE / UNDERSTAND the concepts
- EXPERIMENT & apply judgment to day lighting questions
- UPDATE – Technology changes!
- BE CREATIVE
APPENDIX M. ACTIVE LEARNING: DAYLIGHT MODULE
1. Importance of day light - What? & Why?
2. Sources of day light - From where?
3. Availability of day light - How much?
4. Day light distribution & Interiors
5. Day light integration with other building systems
6. Day light performance issues

DAY LIGHTING - WHAT?
Use of natural light in a building.

DAY LIGHTING - WHY? ...The reasons....

Justification:
1950's : Superior visual conditions
1970's : Energy crunch ... Possible energy savings
Now : Tangible and Intangible benefits

JUSTIFICATION: Physiological benefits:
Full Spectrum Lighting:

UV ....

FOR: Essential for human health & performance
AGAINST: Over exposure to UV
JUSTIFICATION: Physiological benefits:

**Stimulus:**
Changing nature of daylight

**Caution:** Over-stimulation

**Solution:** Avoid excessive stimulation from direct light sources

**Sense of orientation:**
- Relation to the outside
- Feeling of security
- Weather orientation

JUSTIFICATION: Psychological benefits:

**SUNSHINE:**
Direct sunshine in proper location & quantity
- Stimulating & desirable
- Avoid destroying visual acuity

**VIEW:**
Window - Daylight - View, can go together
- Broad horizontal windows
- 20-30% of exterior window wall

JUSTIFICATION: Psychological benefits:

**BRIGHTNESS GRADIENTS & COLOR CONSTANCY:**

- CRI: 100 (Color Rendering Index)
- CRI: 70 (Min. for interiors)

JUSTIFICATION: Energy / Cost benefits:

**Energy consumption:**
- Electric Light - HVAC
- Caution: Heat gain & loss through windows/skylights
- Low U-value glazing assemblies
- Life-Cycle Cost
- Operation/Maintenance Cost

**THINGS TO CONSIDER IN LIGHTING DESIGN**

- **Quantity:** Foot Candles
- **Quality:** Character / visual interest; Easy to the eye
- **Energy:** Overall energy Use
DAYLIGHTING OF BUILDINGS: Specific goals
- Get daylight in
- Distribute the daylight
- Avoid allowing direct sunshine
- Provide controls for the electric lighting

SKYLIGHT

SKY LUMINANCE SKY CATEGORIES CLOUD COVER

SURFACE REFLECTION

Site Features to consider:
- Location
- Adjacent buildings & surfaces
- Trees & Shrubs

SUNLIGHT - How much? - AVAILABILITY in nature

Factors:
- PLACE 42 N
- DATE Apr 4
- TIME 2:30pm / 3:30pm

QUESTION!
Highlight the significance of the image in the context of daylight. What does it mean to you as a designer?
SERI - Solar Energy Research Institute
Daylight Data: Based on Location, month, day, time
Sun angles:
- Altitude angle
- Azimuth angle

LOCATION!!!
**SITE & ORIENTATION**

Orientation - Wall surfaces:

42 N - Ames

- South: East, West, North

Openings to East & West: Low Sun angle

- Horizontal or VERTICAL controls

Openings to South: Ample direct sunlight: needs sun control

Openings to North: Ample indirect sunlight: needs sun control

**INTERIOR SURFACE REFLECTION**

FACTORS:

- Surface quality
  - Color
  - Texture
- Surface orientation
  - Angles of Surfaces
- Space proportion
  - Room Height

**Reflectance of Colors**

<table>
<thead>
<tr>
<th>Reflectance</th>
<th>Specular Surface</th>
<th>Matte Surface</th>
</tr>
</thead>
</table>

**SUNLIGHT - How Much? - SUN ANGLES!**

QUESTION: Analyze the components of the Chart/Image. How will you explain/teach it to another student?
QUESTION A: What daylight design feature does each number indicate?

QUESTION B: Indicate how ceiling slope affects daylight levels?

INTERIOR SURFACE REFLECTANCE

CEILING!

INTEGRATION OF DAY & ELECTRIC LIGHTING

DAYLIGHT CONTRIBUTION IN THE SPACE
- illuminance levels and contours
- Daylight zones
- Temporal variations
- Daylight Distribution changes - adjustable elements
QUESTION: Identify the Lighting Zones! What are 1, 2 & 3?

Building Fenestration & Daylight Zones:

Window  Skylight  Bayside  Roof monitor


DAYLIGHT - CONTROLS
(Fenestration & Lighting)

- 2 switches – Better control
- Luminaires parallel to window – Mimics the daylight zone created by the window wall

DAYLIGHT - CONTROLS
(Fenestration & Lighting)

FENESTRATION CONTROLS
- Static Controls
  - Fixed; Manual
- Dynamic Controls
  - Automated

DAYLIGHT - CONTROLS
(Fenestration & Lighting)

PHOTOSENSORS
1. Interior Open loop:
   - Daylight considered
   - Looks out
   - Remote location
   - Control many luminaires
2. Interior Closed loop:
   - Daylight & Electric light considered
   - Looks into
   - No direct light on sensor
   - Control few luminaires

DAY & ELECTRIC LIGHTING
Two approaches to electric light design:
- To contrast with daylight
  - High at night
- To work together
  - Task/ambient approach
- Ambient electric lighting
- To balance luminance
  - For smoother transition
- To follow daylight zones

DAYLIGHT - CONTROLS
(Fenestration & Lighting)

LIGHTING CONTROLS
- Manual
- Automatic
  - Motion, occupancy sensors
  - Timed response – timer
- Tuning – (continuous dimming, stepped/multi-level switching)
- Photoswitches / photocells
- Photosensors

DAYLIGHT - CONTROLS
(Fenestration & Lighting)

POWER
Logic
Controller
Sensor
Light Source

Two approaches to electric light design:
- To contrast with daylight
  - High at night
- To work together
  - Task/ambient approach
- Ambient electric lighting
- To balance luminance
  - For smoother transition
- To follow daylight zones
QUALITY OF LIGHTING DESIGN!
- Contrast
- Glare
- Veiling Reflection

BRIGHTNESS CONTRAST

CONTRAST is needed for good visual perception.
Caused by: Brightness differences
Depends on: Illuminance (fc) on task, reflectivity of task

QUALITY of LIGHT: Contrast & Glare

Excessive contrast - impedes good visual response

CONTRAST gone BAD! - GLARE!
Excessive contrast - impedes good visual response
Too much of light / reflected light in the field of view
Angled-fluorescent - Reduces Contrast

QUALITY of LIGHT: Contrast & Glare

VEILING REFLECTION (VR)
Result in loss of contrast.
Definition - Reflection of light from specular surfaces that reduce contrast and diminish visual performance
DEALING WITH DAY LIGHTING

- INTEGRATE – Think design as a whole
- BE RESPONSIBLE – Respond to the context
- OBSERVE / UNDERSTAND the concepts
- EXPERIMENT & apply judgment to day lighting questions
- UPDATE – Technology changes!
- BE CREATIVE

Question A:
Direct sunlight is an issue in this space. Identify interior features that help distribute daylight without compromising the designer's comfort & view outside.

Question B:
Identify the interior features in the space that help the day lighting concept.

Light color – High reflectance
- Borrowed light from closed office – High glazing
- The Red partition wall acts like a light shelf and helps distribute light deep into the open office
- Open office plan with low partitions distribute daylight better
- Minimal electric lighting as needed
APPENDIX N. ACTIVE LEARNING: DISCUSSION LIST
20<sup>th</sup> April, 2006

ArtID 353: Active Learning – Day lighting Session

DATE: 20<sup>th</sup> April, 2006 (Thursday) 1.
    2:10pm – 4:00pm

2.

3.

4.

5.

6.

Groups:
18 students: Divided into 6 groups of 3 each. If there are students absent then you can re-group them into 5 groups of 3 or 4 students.

Discussions: The discussion slides are marked with a BLACK STRIPE on the slide

When students are having a discussion within their groups, each student will come up with few points initially, and then they will have to discuss it to narrow it down to few points.

Each student in the group will be responsible for the groups’ answer. i.e., any student can be randomly picked to represent their group and answer the questions.

To minimize time usage, for every discussion, two groups can be asked to discuss the answers with the class. The other groups will pitch in with the left out points.

You could write the main points on the board as students discuss the issue.

(When students need to review images, we can provide them with handouts for the same. Mainly for D2- Slide19, D3- Slide24 & D5- Slide43)
Slides 1-16

**D1:** Slide 17: Daylight Availability: 7mins

The image comes up on the screen and the students are asked to ‘highlight the significance of the image in the context of Day lighting’. What does it mean to you as a designer?

DISCUSSION: Within Group : 3Mins With Class : 4Mins

Slide 18

**D2:** Slide 19: Solar Chart: 13mins HANDOUT!!!!

The chart comes up on the screen and the students are asked to ‘analyze the components of the image’ and discuss how they would teach/explain the chart to another student.

DISCUSSION: Within Group : 5 Mins With Class : 8 Mins

Slides 20 & 23

**D3:** Slide 24: Interior Surface Reflection: 13mins HANDOUT!!!!

**Question A:** What day light design feature does each number indicate?

**Question B:** Indicate how ceiling slope affects daylight levels!

DISCUSSION: Within Group : 5 Mins With Class : 8 Mins

Slides 25-29

**D4:** Slide 30: Daylight Zones: 8mins

Identify the lighting zones. What are 1, 2 & 3?

DISCUSSION: Within Group : 3 Mins With Class : 5 Mins

Slides 31-42

**D5:** Slide 43: Solutions: 14mins HANDOUT!!!!

**Question A:** Direct sunlight is an issue in the space. Find ID solution/s to use daylight without compromising the occupant’s comfort & view....

**Question B:** Identify the interior features in the space that helps the day lighting concept

DISCUSSION: Within Group : 6 Mins With Class : 8 Mins

Slide 44-47
**Group 1: X1-L: LECTURE**

1. “Liked it! Smaller class size always better. Glad you did a lecture on this topic. Info was interesting and stuff we needed to know. Could have done another lecture w/ more info on this topic. Did you send us that could be useful in future. Overall positive experience.”

2. “Liked the smaller more personal class – more attentive. Plus liked having one class that week instead of two. More class interaction.”

3. “Good Review on stuff I thought I know but didn’t…”

4. “Was easier to see the screen and felt more intimate and comfortable. Made me realize that maybe the venue needed to be smaller since the class wasn’t nearly as large. (as the room)”

5. “it seemed, well it is an interesting topic. But I didn’t feel like I gained much from the lecture, because it was just like every other lecture ever. And I don’t understand the point of being split up for it.”

6. “not a far!”

7. “was nice being in a smaller group concentrated to the front but I’m not sure it really was better than lecturing to the full group.”

8. “missed having the rest of the class there. Don’t understand the secret?”

9. “Good overview, but I still don’t think I have it down. We should spend more time on it”

10. “it was ok to be separated. I guess I didn’t really notice too big of a difference.”

11. “Smaller class – I feel is more desirable & effective, students seemed to be more attentive – also helpful in making the students sit close to the front – keeping their attention.”

12. “it was a little more intimate with having less people there, but it was overall like any other presentation/lecture.”

13. “I liked the smaller group – a little easier to pay attention – although I don’t know that there was too much of an impact in my mind.”

14. “Seemed just like any other lecture. I couldn’t figure out why we were split up…”

15. “Seemed like just another powerpoint w/ info we were previously quizzed on.”

16. “Very General… informative confusing”

17. “Cong! Intense about of information – good that we moved closer to the screen & not all spread out.”
<table>
<thead>
<tr>
<th>Group 2: X2-AL: ACTIVE LEARNING</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. “Was able to focus more on lecture because we were constantly discussing in our small groups and then in as a whole – I absorbed the info. better &amp; can still recall almost everything we talked/discussed. I also think it helped that the class size was smaller – more intimate - &amp; everyone was slightly forced to participate.”</td>
</tr>
<tr>
<td>2. “I felt that it was necessary, due to the fact that not many always pay full attention. I felt that it was well worth your time b/c it made people actually learn or have to understand what is going on.”</td>
</tr>
<tr>
<td>3. “I learned a lot. It was hard retaining the information but I am glad I learned it once. So I can use it more effectively in the future.”</td>
</tr>
<tr>
<td>4. “I really learned a lot from the lecture, such as how to read the chart. How to arrange the lighting and tables in the interior against the windows. And the lecture included a lot of detail &amp; information for the daylighting &amp; skylight. There are some exe. to keep me pay attention to the class.”</td>
</tr>
<tr>
<td>5. “I think I was able to be more attentive &amp; less distracted in the smaller group. I’m sad to admit, though, that I don’t feel I actually retained the information much better. I think teacher/student interaction is also better in a small group.”</td>
</tr>
<tr>
<td>6. “More intimate setting for me, allowed me to pay more attention, feel closer to the professor – abve to ask/talk more – and allowed for more effective small group activities and discussions.”</td>
</tr>
<tr>
<td>7. “It was helpful, I feel like I really learned a lot, but why’d we split it up?”</td>
</tr>
<tr>
<td>8. “A lot of material covered for one day! Interesting. I wish I could’ve had a longer time period to remember and retain the info. Sometimes was a bit overwhelming, and hard to just jump into the situation.”</td>
</tr>
<tr>
<td>9. “It was quite useful but a little confusing b/c the activities kept jumping around between topics. It would have been nice to have this lecture earlier in the semester.”</td>
</tr>
<tr>
<td>10. “Good. However I could use a session on lighting in general”</td>
</tr>
<tr>
<td>11. “Very useful. Very informative. Good examples used. Liked being able to talk more in class. Closer, more personal setting b/c there were fewer people &amp; we were grouped”</td>
</tr>
<tr>
<td>12. “Curious as to why it was so secretive, was good in-depth material but group commenting and collaboration didn’t help at all.”</td>
</tr>
<tr>
<td>13. “The daylighting class seemed more organized and interactive. Having the class once a week was nice. It was more quality than quantity!”</td>
</tr>
</tbody>
</table>
14. “I feel the separation wasn’t needed – I didn’t know why we were separated. I further think that the topic of daylighting and reflection should be lectured more. It such an everyday, thing but hard to use in design properly if you don’t clearly know how.”

15. “Was good to have the teams to give answers because it kept the student’s attention...well mostly. If a student goes completely off topic (asks for help w/ another class) just tell them to leave. I couldn’t concentrate completely on the rest of the lecture because I was so horrified. It was one of the more successful ways of lecturing for that class.”

16. “I liked working in groups. it kept me focused on what was going on. I was distracted by ‘x’ working on AutoCAD in front of me. For a class like this laptops should be outlawed – and don’t fall for the “I have to take notes” excuse. it’s not only rude to the professors but it is distracting to other student and rude to guest speakers. If people were more active in the process and interacting with the material they/me learn more and are better focused.”

17. “I think it was helpful esp. those who don’t know anything about Astronomy.”
REFERENCES


