Daylighting Practices of the Architectural Industry (Baseline Results of a National Survey)

M. P. Hattrup

May 1990

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Richland, Washington 99352

SUMMARY

A national survey of over 300 commercial design architects was conducted to develop baseline information on their knowledge, perceptions, and use of daylighting in commercial building designs. Pacific Northwest Laboratory conducted the survey for the U.S. Department of Energy's (DOE) Office of Building and Community Systems (BCS).

In the survey daylighting was defined as the intentional use of natural light as a partial substitute for artificially generated light. The results suggest that architects need to be educated about the true benefits of daylighting and the impacts it can have on a building's energy performance. Educational programs that will increase the architects' understanding and awareness of modern daylighting technologies and practices should be developed by utilities, state agencies, and the federal government.

Such educational programs would require good information on daylighting's actual performance in buildings, thus more performance monitoring studies and case studies should be undertaken. The educational programs would also require the quantification of the positive non-energy impacts (i.e., changes in worker productivity) associated with daylighting. Such information would give architects a powerful tool of persuasion to be used in promoting daylighting to potential clients.

The programs should definitely address each of the following topics: 1) correct applications of daylighting technology and practices; 2) positive impacts that daylighting can have on a structure's total energy use; 3) issues related to control of daylight; 4) information on the payback period associated with various daylighting systems and technologies; 5) appropriate building types for daylighting; and 6) the impact of building codes on daylighting designs.

If more architects can be made aware of the true effectiveness and positive attributes of daylighting systems and technologies, daylighting may be used in more commercial buildings. The results of the survey show that the more familiar architects feel they are with daylighting, the more they use daylighting.

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1.0 INTRODUCTION

In recent years, the United States has been losing its image as the world leader in technology and innovation. Although much of the leading edge of research has been conducted in the United States, it has often been foreign-owned companies, rather than their American counterparts, who have capitalized on these advances. As a consequence, federal agencies have initiated programs to improve the flow of information and the successful adoption of technology by the private sector.

Significant resources have been expended by the U.S. Department of Energy to develop new daylighting technologies during the past 15 to 20 years, yet many of these technologies are underused. The assessment of decision processes and other factors that significantly affect the likely market acceptance and penetration of these technologies has largely been ignored in the past. In response to this lack of knowledge, a recent effort has been made to systematically identify, catalog, and understand architects' and engineers' perceptions of daylighting products and systems. Roberson and Harkreader (1988) conducted focus group discussions with these professionals to elucidate reasons why they do or do not use daylighting systems. Insight gained from Roberson and Harkreader was used to identify issues for the survey reported in this report.

This survey was conducted to develop a more accurate profile of architects' knowledge, perceptions, and use of daylighting in commercial building designs. A more accurate profile of the architects is needed to help identify some of the barriers to commercialization or use of daylighting technologies. Although most of the issues addressed in this survey were identified in the previous focus groups (Roberson and Harkreader 1988), the current methodology allows for greater generalization of results and supports conclusions regarding the relative importance of various issues and perceptions.

One of the problems in studying daylighting is the number of definitions given to it. These range from architectural to lighting energy savings to

total building energy consumption to load management to a cost definition (Selkowitz and Griffith 1986). In this survey daylighting was defined as the intentional use of natural light as a partial substitute for artificially generated light.

Unfortunately this definition does not allow for a clear distinction between an "active" daylighting design and a "passive" daylighting design and is a result of the lack of a clear or accepted definition of daylighting among architects and daylighting experts. Typically daylighting experts tend to define daylighting design to be "active," i.e., any aperture that has fenestration controls that is designed into a building in conjunction with a photo electric control system that will control electric lights to reduce their energy consumption without increasing the energy consumption of the structure's HVAC. The typical practicing architect's definition is more likely to include "passive" designs, i.e., any aperture that is designed to allow natural light into the building for any number of reasons, typically to improve aesthetics and occupant satisfaction.

Thus, a comprehensive definition of daylighting would then be the use of natural daylight to reduce electric lighting and space conditioning requirements, while improving a building's aesthetics and enhancing worker productivity. If this definition were used to define daylighting, very few architects would be able to say they have used daylighting. Oftentimes, one or more of those goals is achieved but rarely are they all attained.

1.1 ANALYSIS OF SURVEY DATA

Several issues were addressed in this survey. Architects were divided, using segmentation analysis, into groups to identify differences among them. The segmentation looked at experience (career length); type of work (designing, managing, etc.); size of firm; type of firm; percentage of time spent on lighting design; and familiarity with daylighting.

Architects' perceptions of daylighting were examined, paying specific attention to the benefits, problems, and payback architects associate with daylighting. Architects' responses to several positive and negative statements about daylighting were also addressed.

Third, architects were asked to give their view of the daylighting decision process. The architects were also asked to rate 1) the importance of certain situational factors on the decision process and 2) the influence of a few key players on the decision process.

The architects were asked to rate eleven building types in terms of how appropriate each is for daylighting. Finally they were asked which sources they rely on for technical and product information and the design aids they preferred for the future.

1.2 STUDY METHODOLOGY

A phone survey of commercial design architects throughout the United States was conducted between January 11, 1989, and February 8, 1989. A random sample of 966 commercial design architects was drawn from the 1987-1988 membership directory for the American Institute of Architects (AIA). With a membership of 55,000 architects, the AIA represents a vast majority of the licenced architects in the United States. The membership directory is probably the most comprehensive listing of architects in the United States who are involved in commercial building design. This listing under-represents young architects in the workforce, i.e., those who have been out of school five years or less. This bias, however, may not represent a significant problem as new architects are not typically responsible for major design decisions such as what lighting system will be used in a building. "Although it is difficult to determine precisely the number of firms in the United States offering architectural services, experience suggests that firms owned by AIA members probably account for 90% of all firms in the industry and about 99% of the industry's business volume" (AIA 1989).

Telephone numbers for some of the sample were available in the directory; others were found through directory assistance. All members of the sample received a letter informing them that they would be called in the near future. Postcards were included with the letters to sample members whose phone numbers were not available. These members were asked to return the postcard with their current phone number. Despite these efforts, phone

numbers for 186 members of the sample remained unknown. Consequently, these members were not included in the survey.

In addition to the 186 sample members without phone numbers, another 187 were dropped from the sample for various reasons: ineligible (retired, non-commercial); disconnected phones; wrong numbers; or deceased. Thus, the actual usable sample consisted of 593 architects.

1.3 USABLE SAMPLE

Of the 966 architects who received the prior letter, 593 were surveyed. At least five call-backs were made to each of the 593 architects in order to schedule and complete the interview. After five call-backs, 460 architects had been reached. Of that 460 architects, 308 completed the interview. Thus, the **cooperation rate** (the ratio of completed interviews to completions plus refusals) was $(308/460) \times 100 = 67\%$. The strict **response rate** (the ratio of completed interviews to completions plus all eligible sample members) was $(308/593) \times 100 = 52\%$.

1.4 ORGANIZATION OF THE REPORT

This report is organized in the following way. Chapter 2 discusses the conclusions based on the results of the research and comments of reviewers. Chapter 3 discusses the segmentation of the architects in terms of size of firm, type of firm, familiarity with daylighting, etc. Segmentation of the architects based on their self-reported familiarity with daylighting produced some interesting results; some of which are discussed in Chapters 4, 5, and 6.

Chapter 4 examines the architects' perceptions of daylighting. These perceptions include the major benefits and problems architects associate with daylighting, their estimates of payback periods for daylighting, and their opinions of daylighting. Chapter 5 examines the decision to adopt daylighting; it discusses who the architects think has the most influence on the decision, and the importance they place on certain situational factors that could affect the decision.

Chapter 6 discusses the architects' perceptions regarding which building types are appropriate targets for daylighting designs. Finally, Chapter 7 discusses the architects' information sources, their use of computer-aided design (CAD) systems, and their preference for new design aids.

2.0 CONCLUSIONS

Daylight used to be the primary source of light; with the advent of safe and relatively inexpensive electric lighting, use of natural light or daylighting took a secondary position. As the 1973 oil embargo forced people to consider how energy might be saved, the use of the sun for lighting needs once again became attractive. Investments in daylighting systems offered opportunities for significant energy and dollar savings (Selkowitz and Griffith 1986). As a result, significant resources have been expended by the U.S. Department of Energy to develop new daylighting technologies since 1973.

It is thought that the effective use of daylighting as part of an overall integrated lighting and building design system can reduce a building's energy consumption by up to 50% (Selkowitz and Griffith 1986). Such reductions can be achieved with the use of design guidelines and tools such as light shelves, skylights, artificial lighting controls, low emittance coatings, and computer simulation. It has become apparent that for daylighting techniques to be effective, there is a need for responsive lighting controls to be developed if the predicted energy savings are to be achieved. Most control systems based on photocells that respond to available daylight are responding to a specific illuminance or luminance level in the space and the relationship between that trigger level and overall occupant satisfaction was never well understood (Selkowitz and Griffith 1986). Thus, employees tended to override the controls to meet comfort needs. This leads to an important issue of the qualitative aspects of light. There are disadvantages of varying intensity and direction of sunlight. However, in addition to the quantitative benefits gained by daylighting, there are qualitative benefits as well: flicker-free light, full spectrum and color rendition, uninterrupted light during daylight hours, productivity and health benefits to the employees.

With all these benefits one would expect widespread use of daylighting; however, there are many barriers (perceived and real) to the implementation of daylighting systems. Recently, practitioners' interest in daylighting practices has waned; as a result, many of the daylighting technologies developed by DOE are not widely used. The current low price for energy is

certainly a contributing factor, but the results of this survey suggest that it is not the only reason for the underutilization of daylighting technologies.

2.1 THE NEED FOR EDUCATIONAL PROGRAMS

Only 22% of the survey respondents felt they were very familiar with daylighting designs and technology.^(a) This group reported using daylighting more often in the past two years than those who said they were less familiar. The survey found that the "less familiar" group used daylighting (this includes passive daylighting) in less than half of the buildings they designed during the past two years.

Taken together, the results suggest that a major barrier to the use of daylight is simply that most architects do not have a basic understanding of daylighting. It follows that if more architects can be made familiar with daylighting, it will be used more often. If this is the case, then programs aimed at educating practicing architects about the correct application of daylighting should be developed.

2.2 TOPICS AND INFORMATION TO BE INCLUDED IN EDUCATIONAL PROGRAMS

Roberson and Harkreader (1988) found that none of the architects in the focus groups had tried to convince their clients to use daylighting features to reduce energy costs. Rather, the primary advantage that they presented to clients was the aesthetic effect. The survey results indicate this is common across the industry. Although positive energy effects were mentioned as benefits a number of times, the underlying theme of the benefits mentioned had to do with different aspects of daylighting's aesthetic effect. The survey found that about 60% of the respondents strongly agreed that daylighting systems 1) improve the satisfaction of building occupants and 2) make a building more attractive. Only 33% of the respondents strongly agreed that daylighting saves energy.

(a) One reviewer felt that number was high, suggesting that some of the 22% who said they were very familiar probably know less about daylighting than they think they do.

These results suggest that any educational campaign should emphasize the positive impacts that daylighting can have on a structure's total energy use. The results also have implications for those who are introducing new daylighting systems or technologies. Until more architects believe in the energy savings available through daylighting, information about new systems should emphasize their impact on aesthetics or visual appeal.

To change architects' perceptions of daylighting's performance there appears to be a need for additional and clearer evidence regarding daylighting's operational effectiveness. Architects were asked what major problems they associated with using daylighting in commercial buildings. The underlying theme for most of the problems related to issues of control (i.e., heat gain or loss, glare, light intensity, cloudy days, etc.). Roberson and Harkreader identified similar problems: many of the architects in the focus groups were concerned about using daylighting in buildings because there was no way to be sure the system would work. An evaluation of Southern California Edison's (SCE) innovative and proactive daylighting seminar program showed that 40% of the participants strongly agreed with the statement "It is difficult to analyze the energy impacts of daylighting options."^(a) All these results are indicative of the difficulty the design community has with understanding the complexity of daylighting design.

An architect's initial uncertainty must be overcome before he/she can be expected to use daylighting designs. It appears that the actual use of daylighting reduces the feeling that it is difficult to analyze daylighting's energy impacts. Of those individuals who actually participated in SCE's daylighting "rebate/shared fees" program, only 15% expressed strong agreement with the statement, "It is difficult to analyze the energy impacts of daylighting options." Thus one can see that once an individual is convinced to try daylighting, the uncertainty surrounding it is greatly diminished. Educational programs like SCE's can be made even more effective in convincing architects to use daylighting for the first time if they can incorporate more monitored data that proves the benefits of daylighting.

(a) Booz-Allen & Hamilton Inc. 1987. Daylighting Program Evaluation Volume II: Report Prepared For Southern California Edison.

Because issues related to control and predictable performance of daylighting appear to be a significant barrier identified in the focus groups, in this study and in SCE's program evaluation, controllability and predictability should be kept in mind during the development of any new daylighting systems or technologies. Lack of control, whether real or perceived, is related to the problem architects have in justifying the economic value of daylighting. Most architects do not feel comfortable in selling daylighting on the basis of energy savings because there seem to be too many things that can go wrong. Until precise credible performance information is available and architects know about it, most will continue to be apprehensive about promoting the use of daylighting. The results of SCE's program also suggest that the experience of using a daylighting system will reinforce the new belief that daylighting's energy impacts can be evaluated and observed.

Information on the payback period associated with daylighting systems and technologies should be included in any educational daylighting programs aimed at architects. The survey results indicate that architects who say they are not very familiar with daylighting systems (12% of the sample) feel that the actual payback period associated with daylighting is beyond what clients will accept. Other information that should be included has to do with costs associated with daylighting systems. Statements that daylighting systems 1) are expensive to purchase and install, and 2) increase building maintenance costs meet with agreement from 57% and 53% of the respondents, respectively. The industry seems uncertain about the costs and energy savings associated with daylighting. The architects who said they are not very familiar with daylighting cannot be expected to actively promote the use of daylighting until they themselves are convinced of its true energy impacts.

While the following survey results are not related to specific educational needs, they should be kept in mind when designing educational materials. The survey found that those who were more familiar with daylighting appeared to have a more realistic view of it. While they cited more problems on average than did those whose self-reported familiarity was lower, at the same time, their view of daylighting was the most positive.

Roberson and Harkreader felt that it would be useful to establish the relative influence of architects and engineers, building developers, and building occupants on the decision-making process for daylighting. They also felt that it would be important to determine what information would have the greatest positive impact on their decision and what type of information would lead them to include daylighting features in a building.

Most of the respondents thought architects had the most influence on the decision to use daylighting. Clients were felt to be the second most influential and lighting engineers the least influential. Seventy-one percent of the architects who felt they were very familiar with daylighting also felt architects were the most influential, while only about 50% of those less familiar felt this way. Thus it appears that familiarity with daylighting increases influence in the decision to use daylighting. This lends further support to the notion that architects should be better educated about the potential of daylighting.

The respondents were asked to rate the importance of six factors to the final decision of whether to use daylighting in a commercial design. The most critical factor appears to be the building's intended function, followed by the local climate, intended building occupants, initial costs versus the costs of alternatives, utility rate incentives, and building codes. Even though building codes had the lowest average importance rating, 40% of the respondents said codes were very important to the decision. This is because the impact of building codes on the use of daylighting varies by community and state. Roberson and Harkreader (1988) found that focus group participants in Los Angeles encountered problems meeting building codes when using daylighting design features, while architects in Chicago encountered no problems with building codes.

The respondents rated several building types on their appropriateness for daylighting. When one daylighting expert reviewed these ratings, he commented that the practitioners' ratings of buildings were at odds with his own perspective and that the practitioners' ratings were not representative of reality. This is the kind of information that this study was intended to identify, i.e., areas where expert opinion and common perception differ.

What the results suggest is that the typical practicing architect needs to be educated with regards to the most appropriate building types for daylighting. The building types are discussed in Chapter 6.

2.3 CHANNELS FOR COMMUNICATION OF EDUCATIONAL INFORMATION

Based on the survey results it is apparent that the educational information developed should be written up in professional journals and publications which were cited as the most important source of information for architects. It is clear that three publications are more popular than the rest: Architecture (or other AIA publications), Architectural Record, and Progressive Architecture.

The second most used channel of communication or source of information is the informal discussion among architects. This finding suggests that another possible approach for communication of daylighting information is to identify key daylighting experts in each state or in major communities. It might also be feasible to recruit architects to become federally certified daylighting design experts for their home community and, as such, serve as information sources for fellow architects in the community. It might even be possible to fund their time when they help competitors with their daylighting designs.

These community or regional daylighting experts could also receive training in the use of the latest computer-based design aids being developed by government and private industry. Currently only 35% of the survey respondents were able to actually name a computer-aided design (CAD) system. The survey results show that while architects want future design aids to be computer-based, they do not want to devote much time to generating computer simulations of illumination levels or energy usage. Access to a recognized local expert or a toll-free technical support line for help in the application of the software (much like the support lines offered by makers of word processing software) might encourage architects to use the software more extensively. If the software is used more often, it follows that daylighting systems would likely be included in building designs more often.

2.4 DEFINITIONS OF DAYLIGHTING

One of the problems in studying daylighting is the number of definitions given to it. These range from architectural to lighting energy savings to total building energy consumption to load management to a cost definition. A comprehensive definition of daylighting might then be the use of natural daylight to reduce electric lighting, heating, and cooling requirements, while enhancing worker productivity and improving a building's aesthetics. Oftentimes, one or more of those goals is achieved, but rarely are they all attained. This was not the definition used in the survey. If this definition were to be used to define daylighting, one industry observer felt that very few architects would have been able to say they used daylighting designs. Because the survey defined daylighting as the intentional use of natural light as a partial substitute for artificially generated light, respondents were able to say they used daylighting more often than if the more comprehensive definition had been used.

The results suggest that 49% of the buildings designed by survey respondents in the past two years included a daylighting component. Several daylighting experts who reviewed the survey results felt this number was very high and had to do with how daylighting was defined. They felt the usage of the more complex "active" daylighting systems that employed the newer daylighting technologies and controls was much lower. Typically daylighting experts tend to define daylighting designs to be "active," i.e., any aperture that has fenestration controls that is designed into a building in conjunction with a photo electric control system that will control electric lights to reduce their energy consumption. Good designs will not increase and may decrease the building's cooling load. The experts were certain that the 49% had to be including "passive" systems that simply allow natural light in but do not use the more complex daylighting technologies and controls. One architect who reviewed the results was asked if his designs included the active or passive daylighting technologies. His response seemed to support the assertions made by the daylighting experts: almost none of his designs incorporated the complex type of systems.

3.0 SEGMENTATION OF ARCHITECTS

The architects were characterized with regards to job experience, the percentage of time they spent on different types of work, the size of their company, the type of company they work for, the percentage of project time they spend on lighting design, and their familiarity with daylighting. Section 3.1 contains results for the entire sample; subsequent sections will discuss some of the interactions between the variables listed above.

3.1 GENERAL FACTS ABOUT ARCHITECTS(a)

The statistics given in this section are for the entire sample. The average architect in the sample has been working for 18 years. Eighty-three percent work at architectural firms; 8% are staff architects with some other type of firm; and 9% have some other arrangement. More than 55% of the architects work at firms with 10 or fewer employees; 18% work with 11 to 25 other employees; 15% with 26 to 100; and 11% with over 100. Most architects spend about equal amounts of time on technical design activities, project management tasks, and "other" activities. On average they spend 35% of their time designing, 33% managing, and 32% doing "other" activities. When asked specifically how much of a project's time is allocated to planning and designing the lighting system, the architects said just under 7%.

Because this study's aim is to develop an accurate profile of architects' knowledge, perceptions, and use of daylighting in commercial building designs, the architects were asked how familiar they were with daylighting designs and technology. These results are presented in Table 3.1. Respondents indicated about one-half of the commercial buildings they had designed in the last two years had a daylighting component.

The level of familiarity with daylighting designs and technology among architects may be a major reason why daylighting has not been used more. As

(a) The sample was drawn from the AIA membership directory which is felt to be a fairly representative subset of the entire population of architects in the U.S.

TABLE 3.1. Architect's Familiarity with Daylighting

<u>Level of Familiarity:</u>	<u>Percent</u>
Very Familiar	22%
Somewhat	63%
Not Very	12%
Not At All	3%

shown in Table 3.1, only 22% of the architects feel they are very familiar with daylighting. This group typically uses daylighting designs more often than those who are less familiar (see Section 3.2). These findings taken together suggest that a program aimed at increasing the average architect's familiarity with daylighting would be worthwhile. The architects' level of familiarity is used to segment their responses to some of the other questions to identify potential relationships. The results from this segmentation analysis are discussed in Section 3.2.

The fact that only about 22% of the architects are very familiar with daylighting also raises a question about the actual use or market penetration of daylighting during the past two years. The average self-reported use figure was 51%. It is not known, however, if the number of buildings designed per architect is constant or variable across "familiarity" categories; thus, the actual penetration figure may be different. Future research should try to establish a per capita design figure for architects, perhaps segmented by size of firm (i.e., the number of buildings an architect designs in a year). A penetration estimate assuming a constant rate of design among architects found the use figure was 49%; this estimate is discussed in Section 3.2.

3.2 SEGMENTATION OF ARCHITECTS BY THEIR FAMILIARITY WITH DAYLIGHTING

The segmentation of architects using their self-reported familiarity with daylighting yielded some interesting results. The most interesting result is the apparent relationship between self-reported familiarity and self-reported usage of daylighting techniques in buildings designed in the past two years. The data indicate that the more familiar an architect is

with daylighting, the more often he or she uses daylighting designs. Sixty-eight percent of the buildings designed (in the past two years) by architects who are very familiar with daylighting included a daylighting component. Only 49% of the buildings designed by those who were somewhat familiar incorporated daylighting, and 27% of the buildings designed by those who are not very familiar have a daylighting component.^(a) Thus, over 75% of the architects used daylighting, but in less than half of the buildings they designed the past two years.

If the number of buildings designed per architect is constant, 49 out of 100 buildings designed the past two years include daylighting components. Table 3.2 illustrates this finding. The calculations use a total number of 100 architects and 100 buildings and assume a constant design rate among architects.

The actual design rate (number of buildings designed in a year/per architect) probably varies by architect but before the actual penetration figure can be approximated, the variability of the design rate must be determined. Future research should attempt to determine if architects who are more familiar with daylighting techniques, design more or fewer buildings in a year than architects who are less familiar with daylighting. If architects who are "more familiar" design more buildings per year, the actual penetration figure would be larger, and if they design fewer buildings per year, the figure would be smaller.

TABLE 3.2. Penetration of Daylighting (DL) Designs in Commercial Building Design

<u>% of (100) Architects</u>	<u>% Past Use of Daylighting</u>	<u>No. of Buildings out of 100 w/Daylighting</u>
22% Very Familiar	68%	$.68 \times 22 = 15$
63% Somewhat Familiar	49%	$.49 \times 63 = 31$
12% Not Very Familiar	27%	$.27 \times 12 = \underline{3}$
Total # of Buildings w/DL		49

- (a) Those who said they were not at all familiar with daylighting technology and designs were not asked how often they had used it in the buildings they designed in the past two years.

Architects working in architectural firms are more familiar with daylighting than are staff architects or those who had some other employment arrangement. Over 75% of all architects said they were at least somewhat familiar with daylighting regardless of the type of firm for which they worked.

Architects working at firms with more than 25 employees are more familiar with daylighting than are those who work at smaller firms. Table 3.3 contains the average response of the architects in each firm size category.

An architect's familiarity with daylighting does not seem to affect the amount of time he or she spends on various activities, except for the 3% who said they were not at all familiar with daylighting. This group spent a definite majority of their time on project management. Table 3.4 contains the average time allocations for design work, project management, and "other" activities, segmented by the architects' reported familiarity with daylighting.

TABLE 3.3. Respondent's Familiarity with Daylighting by Size of Firm

<u>Size of Firm</u>	<u>Mean Response</u>
1 to 10 people	2.99
11 to 25 people	2.89
26 to 100 people	3.24
Over 100 people	3.09

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- (a) The mean score is calculated using the following response codes:
 4 = Very Familiar, 3 = Somewhat Familiar, 2 = Not Very Familiar, 1 = Not At All Familiar. Thus, the higher the mean score, the more familiar the group.

TABLE 3.4. Time Allocations by Level of Familiarity with Daylighting

<u>Level of Familiarity</u>	<u>Time on Technical Designs</u>	<u>Time on Project Management</u>	<u>Time on Other Activities</u>
Average Architect	35%	33%	32%
Very	34%	32%	34%
Somewhat	35%	32%	33%
Not Very	36%	33%	31%
Not At All	39%	45%	16%

Familiarity with daylighting appears to be related to the amount of project time allocated to lighting design. The more familiar an architect is with daylighting, the more time he or she will spend on lighting design. Architects who are not at all familiar with daylighting spend only 1% of a project's time on lighting design, while those who are very familiar spend just over 7%.

3.3 SEGMENTATION OF ARCHITECTS BY TYPE OF FIRM

The amount of time architects spend on lighting design remains about the same regardless of the type of firm at which they work. The frequency with which daylighting designs have been included in the past two years seems to vary based on the type of firm. Architects working in architectural firms used daylighting in 52% of their buildings over the past two years; architects working elsewhere used it in only 45% of their buildings.

3.4 SEGMENTATION OF ARCHITECTS USING SIZE OF FIRM

The two most interesting patterns observed when the sample was segmented by firm size involved the amount of time spent on lighting design and the use of daylighting over the past two years. The amount of time spent on lighting design was about the same for firms with fewer than 100 employees. The architects at the larger firms said they spent 10% of a project's time designing the lighting system. This is 3% to 4% more than architects working at smaller firms spend on lighting design.

Firm size appears to have a weak but observable relationship to the past use of daylighting. Again, it is the architects in the larger firms (more than 100 employees) whose responses suggest a more positive view of daylighting. These architects used daylighting in 59% of their building designs during the past two years. Architects in smaller firms used it in only 50% of their designs during the same time frame.

4.0 ARCHITECTS' PERCEPTIONS OF DAYLIGHTING

This chapter presents architects' perceptions of daylighting technology and designs. Major benefits, major problems, acceptable payback periods, and actual payback periods are discussed. In addition, the chapter contains a discussion of a series of statements (about daylighting) with which architects either agreed or disagreed.

4.1 MAJOR BENEFITS OF DAYLIGHTING DESIGN FEATURES IN COMMERCIAL BUILDINGS

Thirteen categories of daylighting benefits (see Table 4.1) were created from the architects' responses. Ninety-four percent of the architects were able to provide at least one benefit associated with daylighting. A total of 603 mentions was made. On average, architects cited two benefits of daylighting. The most frequently mentioned benefits relate to energy conservation or efficiency, improved aesthetics or atmosphere, and reduced operation costs or monetary savings. The categories and associated frequency of response can be seen in Table 4.1. The "other" category consists of benefits which were only mentioned once or twice.

TABLE 4.1. The Major Benefits of Using Daylighting in Commercial Buildings

<u>Category</u>	<u>Frequency</u>
1 Energy Conservation/Energy Efficiency/Energy Savings	155
2 Aesthetics/Pleasant Psychological Feelings/Atmosphere	142
3 Economy/Reduced Operation Cost/Money Savings	78
4 Quality of Light	60
5 Natural/Connection to Outdoors/Nature Beauty/Outdoor View	52
6 Color of Light/Color Balance/Color Rendition	33
7 Worker Morale/Occupant Productivity/Benefit to Workers	20
8 Makes Room Look Bigger/Perception of Space and Expanse	11
9 Design Quality/Beauty of Facility/Visual Appeal	11
10 Comfort	8
11 Easy on Eyes/Visual Comfort/Changing Visual Stimulus	6
12 Reduced Project Costs/Initial Development Costs	4
13 Other	<u>23</u>
Total	603

Segmenting the responses based on the architect's familiarity with daylighting showed that architects who are very familiar with daylighting cited fewer benefits (2.04) than did those who are only somewhat familiar (2.08), and more than those who are not very familiar (1.65). One possible explanation for this result is that those who are more familiar with daylighting have used it more (see Section 2.2) and, as a result, are more familiar with the complexity of design issues involved. Additional support for this possible explanation can be found in the following section.

4.2 MAJOR PROBLEMS OF DAYLIGHTING DESIGN FEATURES IN COMMERCIAL BUILDINGS

When asked about the major problems associated with daylighting designs, 91% of the architects provided at least one problem associated with daylighting. A total of 485 mentions was made (1.7 problems per architect). The most frequently mentioned problems were related to the lighting control and to heat gains. The categories and associated response frequencies can be seen in Table 4.2. The "other" category comprises problems which were only mentioned once.

Segmenting the problems by the architect's familiarity with daylighting showed that architects who are very familiar with daylighting cited more

TABLE 4.2. The Major Problems With Using Daylighting in Commercial Buildings

<u>Category</u>	<u>Frequency</u>
1 Limited Control/Lack of Control	83
2 Heat Gain	81
3 Glare/Light Intensity	55
4 Weather/Cloudy Days/Night/Availability of Light	49
5 Heat Loss	43
6 Design Uniquely/Difficulty of Design/Meeting Codes	41
7 Installation Cost/Initial System Cost	40
8 Reliability/Leakiness of Skylights	23
9 Maintenance	10
10 Client Reluctance/Hesitancy	9
11 Photo Degradation/Fading/Discoloration	6
12 Occupant Behavior	2
13 Other	<u>43</u>
Total	485

problems (1.78 on average) than did architects who were somewhat familiar and not very familiar (1.60 and 1.47, respectively). This finding, combined with the finding that these architects also cited fewer benefits (see Section 4.1), would seem to suggest that architects who are very familiar with daylighting view it negatively.^(a) To avoid drawing the wrong conclusion, it is important to note that these architects still cited more benefits than problems with daylighting and, therefore, appear to view daylighting positively. Indeed as one daylighting expert pointed out, daylighting's best or strongest proponents (i.e., those who have used it extensively) could probably cite more potential problems than the typical architect.

It must also be remembered that "very familiar" architects employ daylighting more than any other group. It would be intriguing to investigate whether architects who have employed daylighting, and are aware of its benefits/problems, would be inclined to use it again. The answer to this question would be the best indicator of the importance of daylighting's problems relative to its benefits.

4.3 ACCEPTABLE PAYBACK PERIODS AND ACTUAL PAYBACK PERIODS

The payback period is the number of years required for the savings from a new product to pay back its higher initial cost. The payback period for a product has a substantial influence on its rate of adoption. For example, a product with a one-year payback will be adopted at a faster rate and gain a larger market share than will a similar product with a two-year payback. Architects generally felt that the longest payback period a client would accept was seven years. The architects were then asked what they thought the payback period for daylighting was; again, their average response was seven years.

Familiarity with daylighting appears to influence architects' estimates of payback periods. The results indicate that architects who are very familiar with daylighting estimate a shorter payback than do those who are less

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- (a) This appears to contradict the results in Section 3.4 which indicate that the architects who are very familiar with daylighting view it in a more positive light than other architects do.

familiar with daylighting. The average estimates from those who are very familiar was six years; those who are somewhat familiar estimated seven years; and those who are not very familiar estimated eight years. The pattern holds for the responses to the question about the payback period a client would accept. Again, the architects who are very familiar with daylighting estimated six years; both other groups estimated a seven-year payback period was the longest a client would accept. Thus, those who are not very familiar perceive a payback period that is one year longer than the payback period they believe their clients will accept. This suggests that an educational campaign directed at this group of architects should focus on actual payback of daylighting systems.

4.4 ARCHITECTS' OPINIONS ABOUT DAYLIGHTING

The architects were asked whether they agreed or disagreed with ten different statements about daylighting. Six of the statements are positive; four are negative. The architects' responses to the ten statements are shown in Table 4.3.

The architects tended to agree with the six positive statements and to disagree with the four negative statements. Thus, architects generally have a positive opinion of daylighting.

The six positive statements listed in order of agreement (strongest agreement first) are as follows: 1) daylighting systems improve the satisfaction of building occupants; 2) daylighting systems make a building more attractive; 3) daylighting systems improve the productivity of building occupants; 4) daylighting systems are a good value; 5) daylighting systems are reliable; and 6) daylighting systems save energy. These results clearly illustrate that architects do not think of daylighting as an energy conservation measure, but rather as a cosmetic enhancement which improves aesthetics and worker satisfaction. This finding has implications for those who are trying to increase the use of daylighting systems. The impact of

TABLE 4.3. Architects' Opinions on Various Attributes of Daylighting

<u>Daylighting systems:</u>	<u>Strongly Agree</u>	<u>Somewhat Agree</u>	<u>Somewhat Disagree</u>	<u>Strongly Disagree</u>	<u>Mean(a) Score</u>
Make a building more attractive N=293	58%	37%	5%	0%	3.54
Are expensive to purchase and install N=279	7%	50%	37%	5%	2.57
Improve the productivity of building occupants N=280	51%	44%	4%	0%	3.47
Are difficult to integrate with other systems N=286	6%	36%	39%	19%	2.28
Improve the satisfaction of building occupants N=290	63%	37%	0%	0%	3.62
Save energy N=284	33%	49%	15%	4%	3.11
Increase building maintenance costs N=276	10%	43%	39%	8%	2.55
Are a good value N=280	35%	60%	5%	0%	3.29
Introduce more problems than they solve N=282	1%	18%	55%	26%	1.95
Are reliable N=278	27%	59%	13%	1%	3.11

(a) The mean score is calculated using the following response codes:
 4 = Strongly Agree, 3 = Somewhat Agree, 2 = Somewhat Disagree,
 1 = Strongly Disagree. Thus, the higher the mean score the stronger the agreement.

daylighting systems on aesthetics or their visual appeal should be emphasized more than energy consumption if they are to appeal to architects. Though this might appear to contradict the results in Table 4.1, closer examination of that table reveals that responses in categories 2, 4, 5, 6, 7, 8, and 9 are related to visual appeal rather than to energy efficiency.

The four negative statements listed in order of disagreement (strongest disagreement first) are as follows: 1) daylighting systems introduce more problems than they solve; 2) daylighting systems are difficult to integrate

with other systems; 3) daylighting systems increase building maintenance costs; and 4) daylighting systems are expensive to purchase and install. Over 80% of the architectural industry disagreed with the statement that daylighting systems introduce more problems than they solve, and nearly 60% disagreed with the statement that they are difficult to integrate with other systems.

The industry seems uncertain about the costs associated with daylighting systems. Statements that daylighting systems are expensive to purchase and install and that they increase building maintenance costs meet with agreement from 57% and 53% of the industry, respectively. A software package which accurately calculates the energy savings associated with a daylighting design might be very useful in demonstrating to architects that daylighting systems are cost-effective as well as aesthetic.

4.5 ARCHITECTS' OPINIONS ABOUT DAYLIGHTING BY LEVEL OF FAMILIARITY

The architects' responses to these statements about daylighting systems were segmented based on the architects' familiarity with daylighting. The architects who were very familiar with daylighting systems are in Group 1; somewhat familiar, Group 2; and not very familiar, Group 3. Table A.1 in Appendix A lists each group's mean response to each statement. The results in Table A.1 show that the architects in Group 3 tended to have the least positive view of daylighting, and the architects in Group 1 tended to have the most positive view of daylighting.

Although this finding might appear to contradict the observations made in Sections 4.1 and 4.2, it must be remembered that Group 1 architects (those very familiar with daylighting) cited more benefits than problems with daylighting and still had a positive perception of it. Their responses regarding benefits and problems with daylighting probably result from the fact that they have used it more than the other architects.

4.6 ARCHITECTS' OPINIONS OF DAYLIGHTING BY PAST USE

As noted previously in Section 3.2, the architects who were very familiar with daylighting reported using it about 20% to 40% more often than did

those who were less familiar. The results discussed in the previous section indicate that architects' familiarity with daylighting has a positive influence on their view of daylighting. It follows that those who have used daylighting more will have a more positive view of it. To corroborate these results, it was necessary to determine if past use of daylighting was related to the architects' perceptions of daylighting.

To do this, the architects' use of daylighting over the past two years was segmented by their responses to the statements about daylighting. This analysis produced results which indicate that those who have used daylighting the most have the most positive view of it (see Table 4.4). For example, those who strongly agree with the statement that, "Daylighting systems make a building more attractive," had used daylighting in 62% of the buildings they designed the past two years. Those who somewhat agree had used it in only 38% of their designs, and those who disagree somewhat had used daylighting in only 22% of their designs.

Table 4.4 shows that those who had the most positive view of daylighting also used it the most in the past two years (see past use figures in **bold**).

TABLE 4.4. Architects' Usage of Daylighting Related to Their Opinions on Daylighting

<u>Daylighting systems</u>	<u>Used Daylighting the Past 2 years</u>				<u>Mean Score</u>
	<u>Strongly Agree</u>	<u>Somewhat Agree</u>	<u>Somewhat Disagree</u>	<u>Strongly Disagree</u>	
Make a building more attractive N=293	62%	38%	22%	-	3.54
Are expensive to purchase and install N=279	31%	45%	60%	69%	2.57
Improve the productivity of building occupants N=280	62%	43%	33%	-	3.47
Are difficult to integrate with other systems N=286	51%	39%	55%	72%	2.28
Improve the satisfaction of building occupants N=290	60%	38%	-	-	3.62
Save energy N=284	43%	56%	52%	68%	3.11
Increase building maintenance costs N=276	55%	53%	54%	56%	2.55
Are a good value N=280	67%	46%	34%	-	3.29
Introduce more problems than they solve N=282	50%	33%	50%	72%	1.95
Are reliable N=278	65%	49%	50%	26%	3.11

5.0 THE DECISION TO USE DAYLIGHTING: FACTORS AND INFLUENCERS

Architects were asked whether architects, lighting engineers, or clients had the most influence on the decision to use daylighting in a commercial building design. They were also asked to rate the importance of six situational factors which might influence decisions about lighting systems.

5.1 MOST INFLUENTIAL IN THE DAYLIGHTING ADOPTION DECISION

Fifty-five percent of the architects thought architects have the most influence on the decision to use daylighting. Thirty-six percent said clients have the most influence; only 9% said lighting engineers had the most influence. Clients were thought to be the second most influential party by 39% of the architects. Thirty-seven percent thought architects were the second most influential, and 24% thought lighting engineers were the second most influential. Just over two-thirds of the architects surveyed thought lighting engineers have the least amount of influence, on the decision. Over 25% thought clients have the least influence and only about 8% thought architects have the least amount of influence on the daylighting decision.

5.2 FAMILIARITY WITH DAYLIGHTING BY ARCHITECTS' VIEWS OF MOST INFLUENTIAL

The architects' views of who is the most influential in the decision to use daylighting is influenced by their own familiarity with daylighting. About a quarter of the architects who are very familiar with daylighting felt the client had the most influence; nearly 50% of architects not very familiar with daylighting felt this way.

Table 5.1 contains the architects' responses segmented by level of familiarity. The results suggest that familiarity with daylighting gives an architect more self-confidence and, thus, more influence in the daylighting decision.

TABLE 5.1. Familiarity with Daylighting as a Factor of Influence

<u>Level of Familiarity</u>	<u>Person Thought to be Most Influential</u>		
	<u>Architect</u>	<u>Light Engineer</u>	<u>Client</u>
Very	71%	3%	26%
Somewhat	53%	11%	37%
Not Very	41%	11%	49%

	<u>Second Most Influential Person</u>		
	<u>Architect</u>	<u>Light Engineer</u>	<u>Client</u>
Very	26%	18%	55%
Somewhat	38%	27%	35%
Not Very	49%	19%	32%

	<u>Third Most Influential Person</u>		
	<u>Architect</u>	<u>Light Engineer</u>	<u>Client</u>
Very	2%	78%	20%
Somewhat	9%	61%	30%
Not Very	11%	70%	19%

5.3 IMPORTANCE OF VARIOUS DECISION FACTORS

The architects were asked to rate six situational factors that can influence the decision to use daylighting in a commercial building design. The architects were asked to rate factors as very important, somewhat important, somewhat unimportant, or very unimportant to the final decision on the use of daylighting. Table 5.2 contains the distribution of the architects' ratings and the average rating (mean score) for each factor.

As shown in Table 5.2, architects feel the building's intended function is the most important of the situational factors listed. The local climate and the building's intended occupants are also important factors in the minds of the architects. Based on the mean scores the next most important factors are the initial costs compared with the costs of alternatives, followed by utility rate incentive programs and, finally, building codes.

Even though building codes had the lowest mean score, 40% of the architects still said this factor was very important. A possible explanation for this is that the impact (positive or negative) of building codes on the use of daylighting varies from area to area in the United States. Roberson and

TABLE 5.2. Importance of Various Factors on Decision to Use Daylighting

<u>Decision Factors</u>	<u>Very Important</u>	<u>Somewhat Important</u>	<u>Somewhat Unimportant</u>	<u>Very Unimportant</u>	<u>Mean^(a) Score</u>
Local climate N=293	58%	37%	5%	0%	3.53
Intended building occupants N=293	58%	36%	6%	0%	3.52
Initial costs versus alternatives N=293	36%	59%	5%	1%	3.29
Building codes N=291	40%	29%	24%	7%	3.01
Utility rate incentives N=290	28%	54%	16%	3%	3.06
Intended building function N=294	68%	29%	2%	0%	3.65

(a) The mean scores are calculated using the following response codes:
 4 = Strongly Agree; 3 = Somewhat Agree; 2 = Somewhat Disagree;
 1 = Strongly Disagree. Thus, the higher the mean score, the greater the importance of the factor.

Harkreader (1988) found that focus group participants in Los Angeles encountered problems meeting building codes when using daylighting design features, while architects in Chicago encountered no problems with building codes. Although assessing the impact of building codes is beyond the scope of this study, future research to explore this area would be beneficial.

5.4 IMPORTANCE RATINGS SEGMENTED BY ARCHITECTS' FAMILIARITY WITH DAYLIGHTING

The architects' importance ratings of the six situational factors were segmented by self-reported familiarity with daylighting. Again, Group 1 comprises architects who are very familiar; Group 2, somewhat familiar; and Group 3, not at all familiar. The results are shown in Table A.2 in Appendix A.

The results in Table A.2 suggest that architects' familiarity with daylighting does not substantially affect the importance they place on the factors. For example, all the groups felt the building's intended function

was the most important of the six factors. However, Group 1's responses are believed to be more accurate because that group has more experience with daylighting.

Architects in Group 1 (those very familiar with daylighting) rated all the decision factors except "initial costs versus alternatives" in patterns that generally parallel patterns for the entire sample. Group 1 did not feel the cost factor associated with daylighting was as important as did other architects. Only 23% of Group 1 thought cost was very important, while 40% of the other architects thought cost was very important. A possible explanation of this finding may be that as architects use daylighting more, they are able to design daylighting systems which are cost competitive. Future research might be able to determine if this hypothesis is accurate.

6.0 THE BEST BUILDING TYPES FOR DAYLIGHTING SYSTEMS

Architects were asked to rate eleven different building types according to appropriateness for daylighting. The overall ratings are discussed in Section 6.1. Subsequent sections will discuss how the ratings change when the information is segmented.

6.1 RATINGS BASED ON OVERALL SURVEY

The architects were asked if they thought daylighting would generally be very appropriate, somewhat appropriate, not very appropriate, or not at all appropriate for eleven building types. The building types included warehouses, high-rise office buildings, schools, libraries, museums, hospitals, low-rise office buildings, hotels and motels, retail stores, restaurants, and apartment complexes.

Architects felt schools were the most appropriate place to use daylighting designs. Eighty percent of the architects thought schools were **very** appropriate for daylighting. The view that schools are very appropriate for daylighting is very strong and future research should try to determine why schools seem to be so much more appropriate than other building types. One industry observer felt that this was a result of 1950s research efforts.

Low-rise office buildings and libraries ranked next as the most appropriate types. Just over 50% of the architects thought they were **very** appropriate for daylighting designs. Roberson and Harkreader (1988) found that the focus group participants also thought daylighting was appropriate for low-rise office buildings and libraries.

The focus group participants also felt warehouses, hospitals, and museums were among the more appropriate building types for daylighting and high-rise office buildings the least appropriate. These findings are not supported by the results from the survey, which are shown in Table 6.1. The building types are listed in Table 6.1 in order from most to least appropriate.

TABLE 6.1. Appropriateness of Building Types for Daylighting Designs

Building Type	Very Appropriate	Somewhat Appropriate	Not Very Appropriate	Not at all Appropriate	Mean Score
Schools N=293	80%	18%	1%	0%	3.78
Low-rise office buildings N=292	54%	42%	3%	1%	3.49
Libraries N=293	53%	36%	9%	2%	3.40
High-rise office buildings N=293	43%	43%	13%	1%	3.28
Apartment complexes N=292	44%	40%	15%	1%	3.27
Hospitals N=290	35%	48%	15%	2%	3.15
Hotels/motels N=292	35%	41%	21%	2%	3.10
Restaurants N=287	29%	46%	22%	2%	3.02
Museums N=288	30%	39%	24%	7%	2.91
Warehouses N=292	25%	35%	26%	14%	2.70
Retail stores N=292	13%	38%	40%	8%	2.57

High-rise office buildings were the fourth most appropriate building type. This is an intriguing result, as previous research found that high-rises were viewed as inappropriate. Apartment complexes rank fifth followed by hospitals, hotels and motels, restaurants, museums, warehouses, and retail stores.

The view that retail stores are the least appropriate for daylighting should also be evaluated in future research. It would be useful to know what features associated with retail stores, warehouses, museums, etc., make them less appropriate for daylighting. This type of information would be very helpful in targeting daylighting designs to the building types which can most effectively use it.

6.2 RATINGS BASED ON FAMILIARITY WITH DAYLIGHTING

The architects' responses were segmented by their familiarity with daylighting. As stated before, the architects in Group 1 (very familiar) are thought to have the most accurate knowledge of daylighting designs. Because of this, their responses will be discussed. In general, the architects in Group 1 have stronger positive opinions than the other groups on the appropriateness of each of the building types except for libraries, museums, and warehouses.

The most interesting observation resulting from the segmentation was that libraries, ranked third by the entire sample, dropped to seventh among the architects who are very familiar with daylighting. This result is especially interesting because libraries were viewed by the architects in the focus groups and most of the architects in this survey as being appropriate for daylighting.

The architects in Group 1 ranked apartment complexes and hotels/motels higher (relative to other building types) than did Groups 2 and 3 (see Table A.3 in Appendix A for rankings). The ranks associated with each building type are derived using each group's mean "appropriateness" rating. These perceptions were challenged by industry experts. Sixty percent of the architects who are very familiar with daylighting felt that apartment complexes were very appropriate while less than 40% of those in Groups 2 and 3 felt this way. Over 50% of Group 1 also thought hotels/motels were very appropriate; only 34% of Group 2 and 14% of Group 3 felt this way.

7.0 INFORMATION SOURCES AND DESIGN AIDS FOR DAYLIGHTING

The architects were asked what information sources they use and about which technologies they are aware of or have used to aid in designing buildings. They were also asked what type of design aid they prefer and how useful they thought each kind would be. Finally, they were asked to estimate the amount of time they would be willing to spend with the design aids.

The questions about information sources included a list of six generic information sources that the architects rated on importance. The questions about design aids included questions about computer-aided design software and other kinds of design aids, i.e., computer models, physical models, or rules-of-thumb. The results related to these topics are discussed in the following sections.

7.1 THE ARCHITECT'S MOST IMPORTANT GENERIC INFORMATION SOURCE

The architects were asked to name their single most important source of information about new building materials, products, and designs. Some architects named more than one source while a few did not name any. The responses were grouped into eight categories including an "other" category (Table 7.1).

TABLE 7.1. Single Most Important Source of Information About New Building Materials, Products, and Designs

<u>Category</u>	<u>Frequency</u>
1 Trade Magazines/Architecture Magazines/Periodicals	141
2 Sweets Catalog/Commercial Catalog	107
3 Tech. Trade Journals/Architecture Journals/Journals	43
4 Advertising/Mfg. Info./Sales Reps./Lighting Reps.	39
5 Own Imagination/Experience/Visit Buildings	9
6 Professional Assoc./Conventions/Institutes/Trade Shows	8
7 Fellow Architects/Engineers/Consultants	5
8 Other	<u>9</u>
Total	361

Table 7.1 reveals that trade magazines were the most popular generic source for information on new building materials, products, and designs. The second most often mentioned source was the Sweets Catalog or commercial catalogs in general. Following these two categories in popularity are trade journals; information from the manufacturers, sales representatives, etc.; the architect's own past experiences; professional associations, trade shows; and finally fellow architects (word of mouth), consultants. According to the survey, architects obtain most of their information from trade publications and catalogs.

7.2 IMPORTANCE RATING FOR SIX GENERIC INFORMATION SOURCES

The architects were next asked to rate the importance of six generic information sources. Although the six generic sources are somewhat similar to the categories in Table 7.1, the similarity was not planned. The categories in Table 7.1 were created by grouping similar verbatim responses to the question about the single most important information source for each architect. The architects' response patterns (to the six generic categories) are shown in Table 7.2. This rating of the six generic sources establishes the relative importance ranking of each source and will be useful in choosing the best channel for disseminating information.

The findings in Table 7.2 verify that professional journals and publications are in fact the most important source of information for architects, and are comparable to the top three sources in Table 7.1, all of which group easily into a "professional journals and publications" category. Informal discussions with other architects (word of mouth) is the second most important information source according to Table 7.2. This is an interesting result because this source was barely mentioned when the architects were asked to name their single most important sources of information.

Sales people are the next most important source of information for architects, followed by seminars and conferences, trade shows, and university courses. This pattern is fairly consistent with the information in Table 7.1.

TABLE 7.2. Architects' Importance Ratings of Generic Information Sources

<u>Information Source</u>	<u>Very Important</u>	<u>Somewhat Important</u>	<u>Not Very Important</u>	<u>Not At All Important</u>	<u>Mean Score</u>
Professional journals and publications N=304	72%	25%	3%	0%	3.69
Informal discussions with colleges N=303	41%	48%	11%	1%	3.29
Sales people N=303	38%	48%	11%	2%	3.22
Seminars and conferences N=303	23%	50%	22%	6%	2.90
Trade shows N=302	18%	46%	32%	4%	2.79
University courses N=297	15%	34%	38%	14%	2.49

University courses are reported to be the least important source of information on new building materials, products, and designs. Over half of the architects felt university courses were either not very or not at all important as information sources. This finding is somewhat surprising; one industry expert felt the reason architects rate university courses so low may be because they do not have the time to take a full university course. Another possibility is that the curriculum may not have included much on daylighting design when the respondents were in universities.

7.3 SPECIFIC TRADE JOURNALS OR PUBLICATIONS READ BY ARCHITECTS

Finally, the architects were asked what professional journals and publications they read most often. The architects' responses can be seen in Table 7.3. Nearly 70% of the architects named at least three professional journals or publications, and nearly 90% named at least two. These results further confirm previous findings which suggested that most architects rely on publications for information. These verbatim responses were grouped into 16 categories most of which represent the title of a single publication. One is an "other" category containing titles which were mentioned only once.

TABLE 7.3. Professional Journals and Publications Read Most Often

<u>Names of Publications(a)</u>	<u>Frequency</u>
1 Architecture or AIA publication	263
2 Architectural Record	188
3 Progressive Architecture	165
4 Building Design & Construction	32
5 Lighting Design or Lighting (Lighting publications)	17
6 Interior Design/Interiors (Interior design magazines)	15
7 Construction Specification Institute (CSI) Specifier	13
8 Architectural Lighting	8
9 Fine Home Building	7
10 Builder	6
11 Professional Builder	6
12 Restaurant & Hotel Design	6
13 Architectural Review	2
14 Forum	2
15 Sweets Catalog	2
16 Other	48
Total	780

(a) Survey responses showed slight variations in titles. The author has made some assumptions as to the exact journal some architects referred to.

It is clear that three publications have much larger readerships than the rest: Architecture (or other AIA publications), Architectural Record, and Progressive Architecture. Thus, it appears that an organization wishing to get information out to the architectural industry should consider these three publications.

7.4 AWARENESS OF COMPUTER-AIDED DESIGN (CAD) SOFTWARE

Sixty-four percent of the architects said they were aware of computer-aided design (CAD) programs which help them design and evaluate building options. Thirty-six percent said they were not aware of such CAD programs. Those who were aware were asked to name the CAD software they were aware of; only 54% of these architects were actually able to do so. Thus, only about 35% of all architects could actually name a CAD system. Table 7.4 lists the CAD software this group named. Verbatim responses were grouped into 13

TABLE 7.4. CAD Software of Which Architects Were Aware^(a)

Name of Software	Frequency
1 AutoCad	49
2 Versa cad/Versicad	17
3 Intergraph/Entergraph	15
4 Cad/Generic Cad	12
5 Datacad	8
6 Cad Vance/Cadvance	7
7 Arris/Arris-by-Sigma Design/Sigma	7
8 Macintosh/Apple/MacDraw/MacAuto/Mac Hitos Archogram	6
9 Trane & Carrier Energy Analysis Programs/Tranetrace	6
10 IBM (Draft AES)/IBM Compact/IBM-AES	5
11 Anderson Window/Anderson Autocad	5
12 Marvin Windows/Pella Windows/CS400/CS800/Autobus/Cal Pass Micro Pass/Apollo/Fastcad/Cadpack/Lawrence Berkeley/ISACAD Halopane/SKOK/Cadnets/DONN/Cal Comp/Katio/Cad Am/TK Designers Arch Data2/Sunpas/Cascade/DOE 2.1/Quicklite 2/Auto Tro ADC800/Madusa/Point line/Mitsubishi/McDonald-Douglas/Litolier Minicad/Microcad/Prime	28
13 Other	7
Total	172 ^(b)

- (a) Some of the names in this table may be spelled incorrectly or may not be actual CAD software/systems. The results were taken directly from verbatim responses of the architects in the survey.
- (b) Some of the architects who could name a CAD system named more than one, all "mentions" came from only 35% of all architects.

categories, including an "other" category that contains responses which did not appear to be the name of a CAD software system. The results in Table 7.4 clearly show that AutoCAD is the most widely known CAD system in the architectural industry and is the most popular CAD software among architecture firms (AIA 1989). About 47% of the architects who could name a CAD system named AutoCad. Thus about 16% of all architects were aware of Auto Cad; all other CAD systems were much less well known to architects.

7.5 CAD PACKAGES USED BY ARCHITECTS

The architects who said they were aware of CAD systems were asked if they ever used any CAD programs to help design and evaluate building options. Of the 64% who said they were aware of CAD programs, 46% reported having used

CAD programs, and 54% said they had not. Thus, only about 30% of the architectural industry has actually used CAD programs on the job. Those who said they had used a CAD system were asked which system(s) they had used; 80% of this group could name a system. Thus, just under 25% of the architects could name a CAD system they had used. Their responses can be seen in Table 7.5. The results in Table 7.5 clearly show that AutoCAD is the most widely used CAD system in the architectural industry. The results indicate that about 11% of all architects have used AutoCAD and that other CAD systems are used by even smaller percentages of the architectural industry.

It is evident from the results in Tables 7.4 and 7.5 that CAD systems are not used extensively in the architectural industry. Over 75% of the architects could not name a CAD system they had used in the past, and over half were not aware of any CAD systems. These findings suggest that computers are not widely used by the architectural industry to design and evaluate building options. However, interest in CAD software propelled its use among firms from 23% in 1986 to 35% in 1988 (AIA 1989). Although only about 20% of sole practitioners now use CAD, 80% of large firms do (AIA 1989). The reader should keep in mind that large firms only make up a small percent of all the firms in the industry. This increase in usage can be expected to continue as computers become more common in the industry.

The AIA survey report says that more than three-quarters of firms providing architectural services now use computers, up from two-thirds two years ago. The number of personal computers estimated to be in use in such firms across the country has risen from 23,000 in 1986 to 30,000 in 1988. Forty percent of the firms now have 2 or more computers; 10 percent have five or more. Those firms still without PCs are, for the most part, sole practitioners and firms with two to four people; 45% and 31% of these firms, respectively, do not have computers.

The powerful 80386-based computer systems appropriate for CAD applications are becoming more affordable and available. As prices drop, even the smaller firms will be able to afford computer systems that can make full use of CAD systems.

TABLE 7.5. CAD Software Architects Have Used(a)

<u>Name of Software</u>	<u>Frequency</u>
1 AutoCad	32
2 Intergraph	7
3 Data CAD	4
4 Cad/Generic Cad	4
5 Arris/Sigma-Arris/Sigma Design System	4
6 Versa CAD	4
7 Tranetrace/Carrier Programs/Trane programs	4
8 These items were mentioned no more than three times: IBM (Draft AES)/McGraw-Edison/HADCO/Acugraph Series 400 Mountaintop/Sweets Electronic Bld. Files/Micro pass Proximix/ACAD version ID/ Mc Draft/Apple/Mac Alto GDS CADVANCE/Fastcad/Calpas/Isacad/Minicad/SKOK/Power Draw Point Line/Pella Window Program/Hewlett Packard System Tricad/ADC800/McDonald-Douglas/Cascade/Calcom/Doe2.1	30
9 Other	4
Total	93(b)

- (a) Some of the names in this table may be spelled incorrectly or may not be actual CAD software/systems. The results were taken directly from verbatim responses of the architects in the survey.
- (b) Some of the architects who could name a CAD system they had used named more than one; all "mentions" came from only 25% of all architects.

7.6 COMPUTER SIMULATIONS OF INTERIOR ILLUMINATION LEVELS

One of the objectives of this study was to determine ways to increase the use of daylighting designs. As part of this, architects were asked to rate the usefulness of a computer model that would graphically simulate the effect of daylighting features on illumination levels in proposed buildings. Thirty-five percent said it would be very useful; 39% said somewhat useful; 14% said not very useful; and 12% said not at all useful.

All the architects except those who said it would be not at all useful were then asked how many hours they would be willing to spend to obtain a simulation for the average project. Ten percent said they would spend no time; 21% said 1 to 3 hours; 20% said 4 to 6 hours; 20% said 7 to 10 hours; 18% said 11 to 24 hours; and 12% said 25 to 200 hours. The average response was about 13 hours. The average was skewed somewhat by the 1% of the

industry which responded that it would spend between 80 and 200 hours to obtain a simulation. Eliminating this group drops the average response to about 10 hours.

The most important finding for a software developer is that about 30% of all architects said they would spend no more than 6 hours with the software. Thus, if simulation software is developed, it must be easy to use and must provide accurate simulations quickly. One industry observer pointed out that illumination levels alone are not very useful, stating that practitioners need to know load impacts of fenestration to make a decision. This is a valid point, but as Section 7.7 shows, architects indicated they were less interested in the energy effects. This finding implies that some education of the industry must take place before a significant increase in the use of daylighting can be expected.

7.7 COMPUTER ESTIMATES OF THE ENERGY EFFECTS OF DAYLIGHTING

All the architects were asked to rate the usefulness of a computer model that could estimate the effect of various daylighting features on a building's energy consumption. Thirty-two percent said such a model would be very useful; 36% said somewhat useful; 17% said not very useful; and 15% said not at all useful. All the architects except the 15% who said they would have no use for such a model were asked how much time they would be willing to spend to obtain estimates.

Thirteen percent said they would spend no time; 21% said 1 to 2 hours, 20% said 3 to 4 hours; 19% said 5 to 10 hours; 21% said 11 to 24 hours; and 6% said 25 to 100 hours. The average response was about 9.5 hours. This average is also skewed somewhat by a small group of respondents who said they would spend between 80 and 100 hours to get the estimates. Eliminating this group drops the average down to 8 hours.

Information of key importance to a software developer is that 13% would spend no time and 41% of this group would spend no more than 4 hours with a computer model which estimates the effects of daylighting on a building's energy usage. This result suggests that software developed for this purpose must be even faster and easier to use than the simulation software.

Architects do not appear to be very enthusiastic about using software programs to simulate the effects of daylighting on illumination levels or energy usage. Only 8% of the firms used energy analysis software in 1986 and 1988; 5% were expecting to buy it in 1986; only 3% were expecting to buy in 1988 (AIA 1989). Computer simulations of illumination levels are clearly of more interest and use to architects than are simulations of effects on energy consumption. This is probably because architects are typically more concerned or responsible for a building's appearance and aesthetic appeal than for its energy efficiency. Thus, products which are positioned as improving a design's energy efficiency may not be as attractive to architects as products which are positioned as improving a design's appeal.

7.8 ARCHITECTS' PREFERENCES REGARDING DAYLIGHTING DECISION AIDS

The final questions asked of the architects revolve around the preferred form or format of decision aids (i.e., computer model, physical scale model, rules-of-thumb). Architects were first asked if they would prefer to use a computer model or a physical scale model to estimate the effects of daylighting features. Sixty-one percent prefer computer models; 31% prefer physical models; 7% preferred each equally; and 2% did not prefer either.

Architects were then asked to rate the usefulness of rules-of-thumb. Twenty-three percent said they were very useful; 53% said they were somewhat useful; 19% said they were not very useful; and 5% said they were not at all useful in making decisions about lighting. These results suggest that rules-of-thumb are not extremely useful as a decision aid.

Finally, the architects were asked if they preferred rules-of-thumb or a computer-based program to estimate energy use. Twenty percent prefer rules-of-thumb; 67% prefer a computer-based program; 11% preferred each equally; and 2% did not like either of the two options. Although the architectural industry clearly prefers computer-based programs, previous results suggest that even a functional computer model may not be met with much enthusiasm.

8.0 REFERENCES

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APPENDIX A

ADDITIONAL RESULTS OF FAMILIARITY SEGMENTATION

TABLE A.1. The Influence of Architects' Familiarity with Daylighting on their Opinion About Daylighting

Group: 1 = Very Familiar; 2 = Somewhat Familiar; 3 = Not At All Familiar

<u>Daylighting systems:</u>	<u>Sample Mean</u>	<u>Group 1 Mean</u>	<u>Group 2 Mean</u>	<u>Group 3(a) Mean</u>
Make a building more attractive N=293	3.54	3.64	3.54	3.32
Are expensive to purchase and install N=279	2.57	2.32	2.64	2.68
Improve the productivity of building occupants N=280	3.47	3.53	3.44	3.47
Are difficult to integrate with other systems N=286 . .	2.28	1.97	2.36	2.46
Improve the satisfaction of building occupants N=290	3.62	3.74	3.60	3.53
Save energy N=284	3.11	3.03	3.14	3.09
Increase building maintenance costs N=276	2.55	2.52	2.58	2.45
Are a good value N=280 . . .	3.29	3.52	3.29	2.97
Introduce more problems than they solve N=282 . . .	1.95	1.77	1.96	2.27
Are reliable N=278	3.11	3.11	3.14	3.03

(a) The mean scores are calculated using the following response codes:
 4 = Strongly Agree; 3 = Somewhat Agree; 2 = Somewhat Disagree;
 1 = Strongly Disagree. Thus, the higher the mean score, the stronger the agreement.

TABLE A.2. Importance Ratings of Daylighting Decision Factors

Decision Factors:	<u>Very Important</u>	<u>Somewhat Important</u>	<u>Somewhat Unimportant</u>	<u>Very Unimportant</u>	<u>Mean Score</u>
Intended building function N=294 . . .	68%	29%	2%	0%	3.65
Group 1	71	26	3	0	3.68
Group 2	67	31	2	0	3.65
Group 3	72	25	0	0	3.67
Local climate N=293	58%	37%	5%	0%	3.53
Group 1	59	36	5	0	3.55
Group 2	58	38	4	0	3.54
Group 3	53	33	14	0	3.39
Intended building occupants N=293 . .	58%	36%	6%	0%	3.52
Group 1	62	32	5	0	3.54
Group 2	55	40	6	0	3.49
Group 3	69	25	6	0	3.64
Initial costs vs. alternatives N=293 .	36%	59%	5%	1%	3.29
Group 1	23	68	9	0	3.14
Group 2	40	55	4	1	3.33
Group 3	39	58	3	0	3.36
Utility rate incentives N=290 . .	28%	54%	16%	3%	3.06
Group 1	23	58	17	2	3.03
Group 2	29	55	12	4	3.08
Group 3	31	40	29	0	3.03
Building codes N=291	40%	29%	24%	7%	3.01
Group 1	36	26	36	2	2.97
Group 2	40	29	22	9	3.01
Group 3	44	33	11	11	3.11

TABLE A.3. Groups (1,2,3) Appropriateness Ratings of Building Types for Daylighting Designs

Building Type & Rank:			Very Appropriate	Somewhat Appropriate	Not Very Appropriate	Not at all Appropriate	Mean Score
Schools N=293	1		80%	18%	1%	0%	3.78
Group 1	1		83	14	3	0	3.80
Group 2	1		79	20	1	0	3.77
Group 3	1		78	22	0	0	3.78
Low-rise office buildings N=292	2		54%	42%	3%	1%	3.49
Group 1	2		66	29	2	3	3.58
Group 2	2		53	44	3	0	3.50
Group 3	3		36	56	8	0	3.28
Libraries N=293	3		53%	36%	9%	2%	3.40
Group 1	7		50	33	11	6	3.27
Group 2	3		56	36	8	1	3.46
Group 3	2		42	47	11	0	3.31
High-rise office buildings N=293	4		43%	43%	13%	1%	3.28
Group 1	4		49	37	12	2	3.34
Group 2	4		43	43	13	1	3.29
Group 3	5		31	50	17	3	3.08
Apartment complexes N=292	5		44%	40%	15%	1%	3.27
Group 1	3		60	32	8	0	3.52
Group 2	5		39	42	17	1	3.20
Group 3	4		36	47	17	0	3.19
Hospitals N=290	6		35%	48%	15%	2%	3.15
Group 1	8		48	34	13	5	3.27
Group 2	6		32	51	16	2	3.13
Group 3	6		25	61	11	3	3.08
Hotel/motel N=292	7		35%	41%	21%	2%	3.10
Group 1	5		52	32	14	3	3.32
Group 2	7		34	43	22	2	3.09
Group 3	9		14	53	31	3	2.78
Restaurants N=287	8		29%	46%	22%	2%	3.02
Group 1	6		47	39	11	3	3.30
Group 2	9		24	48	25	3	2.94
Group 3	7		25	50	25	0	3.00
Museums N=288	9		30%	39%	24%	7%	2.91
Group 1	9		22	45	23	9	2.80
Group 2	8		32	40	22	6	2.97
Group 3	8		33	22	36	8	2.81
Warehouses N=292	10		25%	35%	26%	14%	2.70
Group 1	11		21	41	23	15	2.68
Group 2	10		26	33	28	13	2.72
Group 3	10		25	31	25	19	2.61
Retail stores N=292	11		13%	38%	40%	8%	2.57
Group 1	10		18	43	32	6	2.74
Group 2	11		12	39	41	8	2.55
Group 3	11		10	28	53	8	2.42

APPENDIX B

SURVEY INSTRUMENT

SURVEY OF COMMERCIAL DESIGN ARCHITECTS - JANUARY 1989

1. Enter Respondent ID number _____
2. Enter Respondent State Code _____ (Note: If area code listing changes, confirm on area code map)
3. Enter Respondent Zip Code _____
4. Enter the Interview Start Time (XXX or XXXX) _____
5. Hello, my name is _____ and I am calling from the Social and Economic Sciences Research Center of Washington State University. May I speak with _____?

[INTERVIEWER: Read if Respondent was not first person to answer phone.]

Hello, my name is _____ and I am calling from the Social and Economic Sciences Research Center of Washington State University.

We are conducting a brief survey on commercial lighting system designs, and would like your opinion on this topic. We recently sent a letter to let you know that we would be calling. Did you receive that letter?

- 1.....Yes
- 2.....No.....
- 3.....Don't Know.....

[INTERVIEWER: Read if letter wasn't received.]

The letter gave a brief introduction to the survey and informed you that we would be calling.

6. Let me start by telling you that this interview is voluntary. If we come to any question that you would prefer not to answer, just let me know and I will skip over it. The questions will only take a short while. OK?

- 1.....Yes
- 2.....No.....

[INTERVIEWER: Read if not OK]

What would be a better time for me to call back?

[INTERVIEWER: Write time on call record]

SECTION A.

7. First, are you an architect involved in commercial building design?

- 1.....Yes
- 2.....No.....

[INTERVIEWER: Read if not commercial]

In that case, that's all the questions I have for you. Thank-you very much for your time.

8. How many years have you been an architect?

_____ Years

9. Are you employed at an architectural firm, as a staff architect in some other type of company, or in some other arrangement?

- 1.....architectural firm / (or consultant)
- 2.....staff at other type of company
- 3.....other

10. Approximately how many people does your architecture firm or department employ? Would you say . . .

- 1.....10 or fewer people
- 2.....11 to 25
- 3.....26 to 100
- 4.....More than 100 people
- D.....Don't Know

- 11-13. Consider how much time you spend doing technical design activities, project management, and other work. I'd like to know the percent of the time you spend on each.

What percent of your total work time is spent on . . .

11. Technical design _____ %
12. Project management _____ % [Enter "D" if DK]
13. Other work _____ %

Total equal (100%) _____

[INTERVIEWER: Read if less than 100%

Your percent total work time doesn't add up to 100%. Do you want to change any of the categories or can you explain why the total is less than 100%? (write explanation on callrec)

14. On average, what percent of the time for a project is allocated to planning and designing the lighting systems?

_____ %

[INTERVIEWER: Enter "D" if Don't Know]

I would like to ask your opinion about the use of daylighting techniques in commercial building design. For our purposes, daylighting is defined as the intentional use of natural light as a partial substitute for artificially generated light.

15. How familiar are you with daylighting designs and technology? Would you say that you are:

- 1.....Very Familiar
2.....Somewhat Familiar
3.....Not very Familiar
4.....Not at all Familiar with.....Go to Q 51
Daylighting Designs and Technology
D.....Don't Know

16. In your opinion, what are the major benefits of using daylighting design features in commercial buildings?

[INTERVIEWER: Probe with statement "Anything else?"]

17. In your opinion, what are the major problems with using daylighting design features in commercial buildings?

[INTERVIEWER: Probe with statement "Anything else?"]

18. About what percent of the commercial buildings you have designed in the last two years have included a daylighting component?

_____ %

[INTERVIEWER: Enter "D" if Don't Know]

19. There is often an incremental cost associated with new products that offer long term savings. The payback period is the number of years it takes for the savings from a new product to pay back the higher initial cost. In general, what do you feel is the longest payback period that your clients will accept?

_____ years

[INTERVIEWER: Enter "D" if Don't Know]

20. In general, what do you think the payback period for daylighting features is?

_____ years

[INTERVIEWER: Enter "D" if Don't Know]

SECTION B.

Q21-30 Now, I am going to read a list of statements about daylighting. For each one tell me if you strongly agree, somewhat agree, somewhat disagree, or strongly disagree. The first one is "Daylighting systems make a building more attractive."

Do you Strongly Agree, Somewhat Agree, Somewhat Disagree, or Strongly Disagree?

Next, Daylighting Systems . . .

[1-Strongly Agree 2-Somewhat Agree 3-Somewhat Dis 4-Strongly Dis D-DK]

21	make a building more attractive	1	2	3	4	D
22.	are expensive to purchase and install	1	2	3	4	D
23.	improves the productivity of building occupants	1	2	3	4	D
24.	are difficult to integrate with other systems	1	2	3	4	D
25.	improves the satisfaction of building occupants	1	2	3	4	D
26.	save energy	1	2	3	4	D
27.	increase building maintenance cost.	1	2	3	4	D
28.	are a good value.	1	2	3	4	D
29.	introduce more problems than they solve	1	2	3	4	D
30.	are reliable.	1	2	3	4	D

SECTION C.

The decision of whether to use daylighting in a commercial building design can be influenced by many people. Please consider the influence of clients, lighting engineers, and architects. Of these, which do you see as the most influential on this decision . . .

Architects, lighting engineers or clients?
Which do you see as . . .

	<u>architects</u>	<u>lighting engineers</u>	<u>clients</u>	<u>don't know</u>
31. most influential	1.	2	3.	D
32. 2nd most influential	1	2.	3	D
33. 3rd most influential	1	2.	3	D

Decisions about lighting systems are also influenced by situational factors. I am going to read a list of factors. For each one please tell me whether you think each is very important, somewhat important, somewhat unimportant, or very unimportant to the final decision of whether to use daylighting in a commercial design. The first one is called "local climate."

Is this factor very important, somewhat important, somewhat unimportant, or very unimportant to the final decision of whether to use daylighting?

[1-Very important 2-Somewhat important 3-Somewhat unimp 4-Very unimp D-DK]

34. local climate	1	2	3	4	D
35. intended building occupants	1	2	3	4	D
36. initial cost compared to alternatives	1	2	3	4	D
37. building codes.	1	2	3	4	D
38. utility rate incentive programs	1	2	3	4	D
39. intended building function.	1	2	3	4	D

SECTION D.

In general, how appropriate do you think it would be to include daylighting in the designs of each of the following types of commercial buildings. I am going to read a list of types of commercial buildings. For each type please tell me whether you think daylighting would generally be very appropriate, somewhat appropriate, not very appropriate, or not at all appropriate for each type of building. The first one is "warehouses."

Would this be very appropriate, somewhat appropriate, not very appropriate, or not at all appropriate?

The next one is . .

[1-Very Appropriate 2-Somewhat 3-Not Very 4-Not At All D-DK]

40. warehouses	1	2	3	4	D
41. high-rise office buildings	1	2	3	4	D
42. schools.	1	2	3	4	D
43. libraries.	1	2	3	4	D
44. museums.	1	2	3	4	D
45. hospitals	1	2	3	4	D
46. low-rise office building	1	2	3	4	D
47. hotels and motels	1	2	3	4	D
48. retail stores	1	2	3	4	D
49. restaurants	1	2	3	4	D
50. Apartment complexes	1	2	3	4	D

SECTION E.

51. For you personally, what is the single most important source of information about new building materials, products, and designs?

Now, I am going to read a list of sources of information. For each one, please tell me how important it is to you in learning about new building materials, products, and designs. Please say whether you think each source of information is very important, somewhat important, not very important, or not at all important. The first one is "professional journals and publications."

Is this source of information very important, somewhat important, not very important, or not at all important?

[1-Very Important 2-Somewhat important 3-Not Very 4-Not At All D-DK]

52. professional journals and publications 1 2 3 4 D
53. sales people 1 2 3 4 D
54. trade shows 1 2 3 4 D
55. seminars and conferences 1 2 3 4 D
56. informal discussions with colleagues 1 2 3 4 D
57. university courses 1 2 3 4 D

58. What professional journals and publications do you read most often?

SECTION F.

59. Are you aware of any computer aided design programs to help architects design and evaluate building options?

1.....Yes
2.....No.....Go to Q63

60. Please tell me the names of the computer aided design software you are aware of.

61. Have you ever used any computer aided design program to help you design or evaluate building options?

1.....Yes
2.....No.....Go to Q63

62. Please tell me the names of the computer aided design software you have used.

63. For you in your current job, how useful would it be to have a computer model that produced graphic simulations of the effect of various daylighting features on the illumination levels in proposed buildings? Would this type of computer model be . . .

1.....Very Useful
2.....Somewhat Useful
3.....Not Very Useful, or
4.....Not At All Useful.....Go To Q65
D.....Don't Know.....Go To Q65

64. Suppose your firm purchased the computer software to develop graphic simulations of the effect of daylighting features on illumination levels in a building. In general, how many hours would you be willing to spend to obtain these simulations for the average project?

_____ hours

65. For you in your current job, how useful would it be to have a computer model that estimated the effect of various daylighting features on the energy needed for building operation? Would this type of computer model be . .

1.....Very Useful
2.....Somewhat Useful
3.....Not Very Useful, or
4.....Not At All Useful.....Go To Q67
D.....Don't Know.....Go To Q67

66. Suppose your firm purchased the computer software to estimate the effect of daylighting features on energy use of a building. How much time would you be willing to spend to obtain these estimates for the average project?

_____ hours

67. To estimate the effects of daylighting features, would you prefer to use . .

1.....A Computer model, or
2.....A Physical, Scale Model?
3.....Neither
4.....Both
D.....Don't Know

68. Many professionals have rules-of-thumb, or general guidelines for when the use of various features is appropriate. Would you say that the rules-of-thumb for daylighting are . . .

1.....Very Useful
2.....Somewhat Useful
3.....Not Very Useful, or
4.....Not at all Useful in Making
Decisions about Lighting.
D.....Don't Know

68. In deciding whether to use daylighting in a design, which would you rather have as a decision aid . . .

1.....Rules-of Thumb. or
2.....A Computer-Based Program to
Estimate Energy use.
3..... Neither
4.....Both
D.....Don't Know

70. Those are all the questions I have for you. Thank-you for taking time to talk with me. If you have any other comments I can write them down now.

71. [ENTER THE ENDING TIME] (XXX OR XXXX) _____

72. [ENTER THE TERMINATION CODE]

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