

User Evaluation of Visual Comfort in Some Buildings of the Daylight Europe Project.

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ABSTRACT

Use of daylight in combination with electric light should lead to considerable saving in electricity in many types of buildings as compared to a system using only electric light. The Daylight Europe project evaluates different ways to use daylight efficiently in new and old buildings. A technical solution is however not successful if the user of the building is not satisfied. User evaluations, so called post-occupancy evaluations (POEs), have been tried in some of the buildings to establish both a method that can be used in other buildings and to evaluate how successful the chosen system is.

We describe how a formal POE should be performed and also what can be achieved if not all conditions are fulfilled. Very few of the buildings in the Daylight Europe project were suitable for a formal POE. Other obstacles the researchers can encounter are also discussed.

The questionnaire proposed and used is found as an Appendix.

INTRODUCTION

The basis for the project Daylight Europe is a strong belief that there is a large potential for saving electric energy for lighting if you use the daylight in combination with artificial light (electric light).

Technical development both in light sources and control equipment makes it possible to have the amount of electric light you want when and where you want it and at a lower cost for the equipment. If you can reduce the use of electric light further by using daylight the saving can be even larger. As the cost of electricity most certainly will increase there is a need for the new technology. Also when retrofitting old buildings you can make the installations very cost efficient.

There is no doubt that you can create a good lighting quality both with daylight, electric light or a combination. If it is good is decided in the end by the user. The user is thus the ultimate target and also obstacle. He/she must experience the technology as meaningful and positive to the environment. If not, the building will not be accepted. Consequently, a study of the technical possibilities to save energy by using daylight in combination with electric light is not really meaningful if you don't study the user's reaction as well as the energy use.

HOW TO EVALUATE THE USER REACTION

There are in fact only two ways to get a user reaction: measure his/her performance in some way or attitude to the environment. The latter is generally done in a so called POE.

In a project like Daylight Europe, where the buildings are of very different type and size and only studied for a relatively short period, it is impossible to get a measure of performance that gives reliable empirical data making it possible compare buildings and daylight systems.

Thus, you must ask the users of the buildings about their attitudes. This is also difficult if you want to be able to compare the lighting of different buildings, due to both the variations in lighting conditions in a specific building over the year and the variation between persons. To be able to really evaluate one system against another you would prefer to have the same group of persons to experience and evaluate both systems, a so called *within-person* design. The number of persons should be at least 15 in a homogeneous group.

The alternative is a *between-person* design where different

persons are exposed to the different situations. Since people are genuinely different the variance in between-person design is greater than in within-person designs, and consequently more persons are needed in the between-person designs to make a real difference in means come out statistically significant.

As a rule of thumb 30 persons or more are needed in each group in between-person designs, if they are properly matched on characteristics such as age, sex, education, health, type of work etc.

In most of the buildings in Daylight Europe the number of occupants is small and it has not been possible to make changes in the lighting conditions during to project. This reduces the number of buildings where you can make a "formal evaluation". By formal we mean an evaluation where you have a possibility to really say something about the quality of a lighting system from the users point of view and compare it with a different solution.

Informal evaluations can, however, be made, but then you can not tell much about the quality of a system or make any comparisons between systems.

WHEN SHOULD YOU DO THE EVALUATION?

If you ask the user to evaluate the lighting condition at a specific time you will get an answer that is influenced not only by the lighting situation at that moment but also by the user's mood and feelings at the same moment. As we are studying daylighting in combination with electric light, the light conditions are varying, not only with season but with time of day and the weather conditions. Thus, there is a risk that the answers reflect the conditions just at that moment, conditions that perhaps are not very typical.

The only way, we think, to get a fairly true picture of the quality of a lighting system is to ask the user to evaluate it over time. This means that the user must have experienced *different* daylight conditions and work situations and got a feeling of both the merits and disadvantages of the system. Evaluating over time also gives more detailed information about when and where problems can arise. Of course the conditions at the moment of the asking the questions can have a marked influence on the answers especially if the conditions are unusual at the time. By phrasing the questions carefully you try to get the occupant to think about the conditions experienced during different times of the year and give an evaluation over time, with the possibility to indicate under what circumstances the conditions are particularly good or bad.

When a system and a work room is new to the user there is also a risk that he or she has a more positive or negative attitude to the conditions. This attitude to the new conditions should be avoided as it does not give a true evaluation of the lighting system and the building. The user must thus have been working in the building for quite some time before you do the POE, preferably a year if you really want to get an evaluation of different conditions.

If you introduce a change in the lighting system to make a within-person evaluation you must give the user a period to become familiar again with the new conditions before doing a new POE. Also in this case preferably a year. If this is not possible you should at least give the

occupants 2 months to experience variations in the climatic conditions. The user should preferably experience the two systems under the same period of the year to make the comparison between the answers valid. However, a spring period could be compared to a fall period with about the same daylight situations.

As we are working under daylight conditions you can also get very different weather conditions during the periods you compare. If you can have one group of users in a building experiencing a new system and one group who continues with the same system you improve the possibilities to compare the systems as the second group will be a control, also experiencing one system under the two periods.

WHAT TOOLS CAN YOU USE TO MAKE A USER EVALUATION?

As you can't make any reliable performance measures in this project, you can either interview the user or present the questions you would like to get answers to in a questionnaire. As it was impossible to have the same persons interviewing users in different buildings in different countries we have proposed a questionnaire that can be used by all teams.

Several questionnaires have been used by researchers over the years. One problem is that many are constructed for a specific project and used just once. It is thus difficult to tell which is the best and most reliable for a study like Daylight Europe. Within the CIE (Commission International de l'Eclairage) a technical committee is studying the possibilities to make POEs and is collecting questionnaires and other evaluation tools. A final report is not yet available.

QUESTIONNAIRE

The questionnaire proposed for the project is the result of a survey of reports from POEs and similar studies. It is to a large extent based on a questionnaire constructed and used, as it seems successfully, for POEs of government buildings in the USA constructed by Elder et al (1979) and also reported by Collins et al (1989).

The questionnaire consists of 37 questions that cover the attitudes to the building as a whole, the work station, lighting and other environmental factors such as thermal and acoustical conditions, privacy, view etc. The major part is of course on lighting, both daylight and artificial light. There are also questions about how the workplace is lit, if the windows create problems, the attitude to windows as such with advantages and disadvantages of windows. The worker's position in relation to the nearest window is recorded and the orientation of the window can be found from the drawings. Finally, data concerning age etc of the respondent and about how long he or she has been working in the building are also collected.

The user is asked to give an opinion on how the conditions are experienced over time and to try to tell when problems arise, if they do.

The identity of the user is not revealed but an identification is asked for, enabling us to compare the evaluation from one occasion to another.

For each building additional questions are allowed if there are some special features that are of interest to evaluate. Some questions might on the other hand be irrelevant for the specific building and should then of course be removed from the form. If you delete and/or add questions the numbering of the basic ones should be kept to facilitate comparison between results from different buildings. New questions should also get new numbers outside the ones used in the basic questionnaire.

MEASUREMENT OF THE PHYSICAL ENVIRONMENT.

In the Daylight Europe project the POE is a complement to the monitoring of the building performance with respect to energy consumption and illuminances on the workplaces etc. From these monitorings it is possible to describe the lighting conditions in detail for certain periods of the year and by modelling for other parts and other climatic conditions.

The result of the POEs should be discussed with respect to the lighting conditions achieved and the energy performance of the building when comparing different window systems and control strategies for the daylight and electric light.

In buildings where you don't have the same formal monitoring any POE must be related to recordings of the lighting conditions on the workplaces and for the building as a whole. How to do these monitorings is described in the report from the project.

POE-BUILDINGS IN THE DAYLIGHT EUROPE PROJECT

Formal POEs.

Out of all the buildings in the project, eight are evaluated in some way by the questionnaire. Only three of the buildings, all offices, have enough occupants to form a good basis for a formal POE. In one university laboratory a slightly different questionnaire was issued at an early stage. Possible buildings have also dropped out due to problems in getting the employer's permission to carry out the POE.

The buildings with the largest number of occupants in identical or similar rooms are the Statoil Building in Trondheim, Norway, and the Scottish Office in Edinburgh, UK. Especially the latter would be perfect for a formal POE as the control system for the artificial lighting is very flexible and the total number of employees is about 1200. As the building owner in the end was reluctant to allow a large scale survey we have made the POE only in a small part of the building where a work team will experience different control strategies for the lighting. Only one survey has been carried out. This is of course unfortunate for the project. We still hope for permission to do a full-scale survey. However, this will be too late to report within the Daylight Europe project.

In the Statoil Building the special control system will be removed from the experimental rooms and the standard lighting system installed again. This would give a very good experimental situation with a control group as reference both during the project period and after. The problem is that this will not be available for evaluation until after the end of the project.

In the LNEC building in Lisbon, Portugal, different use

of external awnings will be studied. The second survey will be in April 1977.

Informal POEs.

In Queen's Building, which is a laboratory building within the De Montfort University in Leicester, UK, a slightly modified POE questionnaire was used and issued to some 50 students and 10 staff. No changes in the lighting has been introduced and the survey can only be regarded as an informal POE.

In Beresford Court office building in Dublin, Ireland, an effort was made to change the switching system for a second survey late in spring 1997. The first survey of the 25 occupants will only be an informal POE.

In Domino Haus, Reutlinger, Germany, the situation is similar. A first survey has been made but effort will be made to change the lighting system for a second POE. The number of occupants is however fairly small.

The Architects' office in Athens, Greece, has daylight from skylights. The only possible change in lighting is to block the skylights and see what the reactions are to purely artificial light compared to the original lighting situation. Datacollection for two timeperiods, with a change in between, has been done but no results are available yet.

Finally there is an interest in doing a POE in the E.O.S. office in Lausanne, Switzerland. The number of occupants is also in this building limited and no results are yet available.

SUMMARY

To be able to make a reliable evaluation of the users attitudes to their work environment you must be very strict in meeting certain experimental conditions. If not, you can't claim to have an adequate estimate of the quality of the environment. This restriction has shown to limit the number of possible buildings in the Daylight Europe project.

Adding the difficulties to get permission to present a questionnaire to the occupants and to make changes in the lighting system in a controlled way to create a good experimental situation, the project has failed to get results within the time limit. There is still some hope to get a possibility to continue in a few buildings and to use the results for later presentations and also in the IEA Task 21 project, which to some extent adds to the Daylight Europe project. ●

REFERENCES

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APPENDIX

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1996-05-31
your building's name.....

Lighting conditions survey

This building is one of many buildings in different parts of the world which are being monitored.

The aim of this survey is to gauge the opinion of occupants on the lighting conditions. The survey complements measurements of daylight and artificial light as well as energy consumption.

Please complete and return the questionnaire as you are instructed.

Be frank and honest in your answers.

Your answers will only be used as part of a statistical analysis and it will not be possible to identify any person individually. At the end of the questionnaire you will be asked to give a personal identification that you can remember if you are asked to fill in the questionnaire again at a later time.

Thank you very much for your time and cooperation.

Name and address of person responsible for the survey
QUESTIONNAIRE

Date:.....

First a few questions about the building

1. Is there anything you particularly like about the (name of building)?

- O Yes
O No

If yes. What do you like?.....

2. Is there anything you particularly dislike about the (name of building)?

- O Yes
O No

If yes. What do you dislike?.....

Then questions related to the conditions in your work area

Identification:

Floor:..... Room number:.....

Other id:..... or work area name

3. Please read all the categories and then mark the kind of work area you are in (only one alternative).

- O A private room enclosed with full height walls
O A room enclosed with full height walls, shared with one other person
O An open room (no dividers or furniture that blocks the view) shared with 2 or more other persons
O An individual space enclosed (or mostly enclosed) by dividers, plants or file cabinets etc. in an otherwise open office. Have little or no view of other employees

- O Have some dividers, plants, file cabinets that tend to break up an open room but do not enclose the work space. Can easily see other employees.

4. How many persons share your current room or work space?

- O Have a room of my own.
O Two persons
O 3-4 persons
O 5-10 persons
O More than 10

5. Mark the three physical features that are most important to you in making a work place a pleasant one for you to work in. Mark from 1 to 3, with 1 = the most important.

- O Comfortable temperature
O Freedom from noise
O Good light
O Privacy
O Good ventilation
O Plenty of space
O Window(s)
O View out
O General environment
O Other (please specify) (colours, carpet, decoration).....

6. How satisfied are you with the following aspects of your work place?

Very satisfied, Somewhat indifferent, Somewhat satisfied, dissatisfied, Very dissatisfied

Table with 10 rows (a-j) and 5 columns of radio buttons for satisfaction levels.

7. Do you have a desktop lamp or similar at your work-place?

- O Yes
O No

If Yes, do you use it

- O Always
O Often
O Seldom
O Never

If No: Do you think that a desktop lamp would improve your working conditions?

- O Yes
O No

8. Do you prefer working in natural light, artificial light or a combination of natural and artificial?

- Prefer natural
- Prefer artificial
- Prefer combination

9. In general how do you rate the light level, artificial and natural combined?

Too little light, About right, Too much light

- a. at the workplace
- b. in the room in general
- c. at the VDU

10. Does the artificial light ever cause glare strong enough to bother you?

Often, Sometimes, Only occasionally, Never

- a. at the workplace
- b. at the VDU

11. Does the daylight ever cause glare strong enough to bother you?

Often, Sometimes, Only occasional, Never

- a. from the sky
- b. from the sun

12. Does the lighting cause reflections in your work material?

Not disturbing, Slightly disturbing, Moderately disturbing, Very disturbing

- a. from the ceiling lighting
- b. from desk top lighting
- c. from the daylight

13. If there are reflections that disturb you, in what work material do they occur?

- Glossy paper
- VDU screen
- Other (please specify)

14. What is your general impression of your room/work area? (Mark as many as apply)

- Bright
- Dark
- Good colours
- Unevenly lit
- Other (please specify).....

15. How important is it to you to have a window in your room or immediate work area?

- Very important
- Moderately important
- Not important

16. Do you have a window in your room or work area?

- Yes
- No

If no go to item 26

17. How is your workplace orientated in relation to the windows? Please indicate your position (point) and main viewing direction (arrow) in a sketch over the room/work area. Give the approximate distance to the nearest window.

18. Are you right handed or left handed?

- Right handed
- Left handed

19. Are you able to see as much of the outside world as you would like from your workplace/desk?

- Yes
- No

20. Which of the following best describe the view out of the window closest to you? (Mark as many as apply)

- satisfying open
- limited bright
- simple uncluttered
- pleasant frustrating
- confined complex
- dim boring
- stimulating unpleasant
- cluttered spacious

21. Do you ever work using only the light from the windows?

- Often
- Sometimes
- Only occasionally
- Never

If it happens, can you specify when?

22. Does it ever become too hot because of the sunshine coming in through the windows?

- Often
- Sometimes
- Only occasionally
- Never

If it happens, can you specify when?.....

23. Can you control the heat radiation through the windows?

- With external blinds or similar devices
- With internal blinds
- With curtains
- Other ways (please specify).....
- No

24. Do you ever notice cold draughts near the windows?

- Often
- Sometimes
- Only occasionally
- Never

25. How about the size of your window, is it:

- too big
- about right
- too small

26. Listed below are some of the advantages of windows. Mark the three that are most important to you at your workplace. Mark from 1 to 3, with 1 = the most important.

- Let you tell the time of day
- Let sunshine in
- Let you know what the weather is
- Let in warmth
- Let you see what is going on outside
- Provide light for plants
- A way for fresh air to enter
- View out
- Make room seem more spacious
- Break monotony
- Other (please specify)

27. Listed below are some of the disadvantages of windows. Mark the three that you feel are the biggest disadvantages at your workplace. Mark from 1 to 3, with 1 = the most important.

- Let in too much heat in summer
- Cause glare
- Let in too much cold air in winter
- Reduce privacy
- Limit ways furniture can be placed
- Let in outside noise
- Give too much sunlight
- Present a hazard (might brake)
- Present a hazard (person might fall)
- Other (please specify)

28. Which of the following activities are a normal part of your job? Mark each one you usually do as a part of your job with 1 for the most common activity.

- Using PC or other keyboard machines
- Reading
- Typewriting
- Writing by hand
- Filing
- Working with numbers
- Making drawings
- Laboratory work
- Using the telephone
- Interviewing or holding small meetings
- Supervising the work of others
- Other (please specify)

29. In general how much time do you spend in your office or immediate work area?

- All the time (7-8 hours a day)
- Most of the time (4-6 hours a day)
- Very little (less than 4 hours a day)
- Other (please specify).....

30. Do you consider yourself as very sensitive to glare?

- Yes
- No

31. Do you wear glasses or contact lenses when working?

- No
- Yes

If yes

- Simple
- Progressive
- Bi-focals
- Contact lenses
- Special glasses/lenses for VDU work

32. Do you often wear sunglasses indoors and outdoors?

- Yes, outdoors
- Yes, indoors
- No

33. In general terms, what kind of job do you have? (For example clerk, typist, supervisor, physician, etc).....

34. If you have any further comments about the building please write them here:.....

The following information is needed for data analysis only. It will not be used to identify any individual respondent.

35. How long have you been working in the
.....(name of building)?

36. Sex

- Female
- Male

37. Age

- Under 30
- 30-39
- 40-49
- 50-59
- 60 and over

Please chose any combination of digits and/or letters as your personal code and remember it until you may be asked to fill out the questionnaire again in the future. The purpose of this code is only to make it possible to find out if there are changes in a person's response when the lighting conditions change. Only you know your code!

In order for you to remember the code, chose events or persons of personal importance and take their names or the date, year and month of the event, the name of the place or the event etc.

Code (digits and/or letters).....

Thank you for completing the questionnaire.

Session 7

Methods of Assuring Quality

