Daylighting Education in Practice

Verification of a New Goal within a European Knowledge Investigation

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Daylighting Education in Practice

Verification of a New Goal within a European Knowledge Investigation

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ABSTRACT: Two independent surveys were conducted in 2017 and in 2018 among architecture students across Europe to investigate their knowledge on daylighting and the impact of that knowledge on the visual perception of daylit spaces. A total of 600 responders were involved. This paper presents findings from the second survey, which was distributed in six European countries. Based on the findings from the first survey, a new goal was set for the second survey: to examine how daylighting knowledge may influence the visual perception of it and how the perception of a daylit space by a student population and by experts compare to each other. Three main findings were observed: i) the perceived comfort shows a better agreement with mood than with sky condition; ii) the judgments expressed by the experts and by non-experts are consistent with each other, confirming an outcome of the earlier study and iii) there is a lack of knowledge about daylighting metrics and regulations as well as a difficulty in implementing daylighting into the design process. These outcomes highlight the relevance of reconsidering the way daylighting education is delivered in current architectural programmes.
KEYWORDS: Survey among students; Experts vs. Non-Expert; Knowledge on daylighting, Perception of daylit spaces; European education.

1. BACKGROUND

Daylight is widely considered as a strategic resource towards a human-centred and energy efficient approach to the design of the built environment. Linked to both visual performance and comfort, daylight fosters attentiveness, interaction and communication. It stimulates mood and well-being via image forming and non-image forming processes and given its impact on the human circadian rhythm, is it also regarded as an important resource for the creation of healthy indoor environments. Often regarded as a design driver [1], daylighting can also lead to optimal solutions regarding form, function and usage of technology in building design [2]. The importance of rethinking the role of daylighting in building regulations and practice is furthermore demonstrated by the work of the Comité Européen de Normalisation (CEN) (Technical Committee CEN/TC 169) on the new European Standard on *Daylight of Buildings* [3, 4].

However, despite all the benefits, many building practitioners are still unable to optimise daylighting in their projects. According to a study by the International Energy Agency (IEA) [5], the practical application of the latest daylighting assessment methods and metrics remains quite limited. There is a tendency to rely on simplified calculations, experience, and rules-of-thumb in the early design stages [6, 7].

Within this context, this paper presents a selection of the results from DAYKE (DAYlighting Knowledge in Europe), a project aimed at exploring the knowledge on daylighting and its impact on the visual perception of spaces. Two independent surveys were conducted in 2017 and in 2018 among architecture students, 600 participants in total. This paper focuses on how daylighting knowledge of architecture students is manifested:

(a) by the perception of the daylighting conditions in their classrooms;
(b) in their education and implementation in the design process.

2. THE DAYKE PROJECT

The motivation behind DAYKE is a belief that a better awareness of daylighting should result in smarter and healthier buildings. Based on that, DAYKE investigates the current level of daylighting knowledge among students and practitioners of architecture across Europe.

The DAYKE framework is composed of six areas of investigation. There are three main areas: i) perception of the daylit space; ii) knowledge about daylighting

standards and regulations and iii) preferences; and three secondary areas: iv) educational offer; v) professional training and vi) cultural aspects.

Overall, DAYKE is meant to provide an overview of the daylighting knowledge and training to all building sector stakeholders in Europe.

2.1 The DAYKE toolkit

According to the conceptual design of the research, a set of tools was created to investigate selected topics at different stages. These tools have specific goals and target different categories of respondents:

- **Stage 1:** Questionnaires A (Q-A and later Q-AR) targeted architecture students. They were designed to assess students' ability to observe and describe daylight conditions in a given space (*perception*). The questionnaires also investigated cultural preferences and knowledge about daylight metrics/indicators and regulations.
- **Stage 2:** Questionnaire B (Q-B) will be directed to university students and practitioners. The goal will be to evaluate the daylighting preferences and corresponding design practice.
- **Stage 3**: Questionnaire C (Q-C) will aim at evaluating the daylight educational programmes and training courses across Europe.

3. FIRST STAGE: ARCHITECTURE STUDENTS' DAYLIGHT PERCEPTION AND KNOWLEDGE

Stage 1 consists of two different surveys carried out in 2017 and 2018. The first survey, which used questionnaire A (Q-A), was a pilot study and involved 250 people from architecture schools in five countries (Germany, Italy, The Netherlands, Poland and Spain). The method and the main results were presented in detail in [8].

The second survey, which used a revised version of questionnaire A (Q-AR), is run in two sessions: spring and fall 2018. Nine countries are involved (Denmark, France, Germany, Italy, The Netherlands, Poland, Spain, Switzerland and the United Kingdom) with approximately 1000 subjects.

This paper presents the results of Q-AR from the spring session, with 350 people of seven schools of architecture from six countries (France, Germany, Italy, The Netherlands, Poland, Switzerland).

3.1 Survey Q-A: a preliminary study

The first survey was as a preliminary enquiry to confirm literature findings and to test the research protocols. The Q-A covered three areas of investigation: i) *perception*; ii) *preferences* and iii) *knowledge* (Fig. 1). The *perception* evaluation was based on a benchmark method that compares the judgments of "experts" (lecturers, PhD students and professionals) and "non-experts" (students) [9]. The investigation on *perception* relied on 5-point scales whereas open or multiple answers questions were used to investigate *preferences* and *knowledge*. Illuminance values were also measured during the questionnaire to investigate potential correlations with the subjective judgments.

The first outcomes of the survey were presented in [8] while the complete results of the Q-A survey are the subject of a future publication. As a summary, four major tendencies have emerged from the analysis of Q-A:

T1. Significant differences of knowledge per country were observed regarding the daylighting design know-how, preferences and expectations. Students from different countries also paid a different degree of attention to distinct aspects of daylighting design. However, no major differences in subjective preferences on daylighting were found between southern and northern countries.

T2. There were no substantial differences regarding the perception of the daylight quality of the classrooms between students and experts.

T3. A distinctive influence of the educational programme on the students' responses was found.

T4. Most of respondents had no knowledge about daylight standards and regulations.

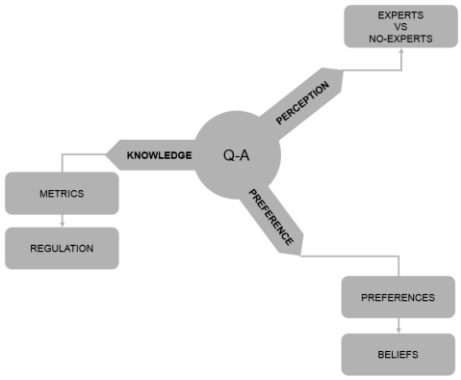

Figure 1: Areas investigated in Q-A.

3.2 Q-AR survey: a targeted study

Based on the experience gained from the first survey, the questionnaire was revised to improve its effectiveness and interpretation as well as to expand the areas of investigation. In this way, Q-A served as an instrument to understand the main tendencies, while the Q-AR served to verify research goals derived from Q-A.

Evolution from Q-A to Q-AR

The main strengths of Q-A turned out to be: i) the simplicity of the tool; ii) a great interest and response from architecture tutors and iii) the cross-national character of the research. On the other hand, the weaknesses were: i) problems with data collection and cataloguing of open answers; ii) the rudimentary in-situ measurement method and the difficulty in using illuminance data for non-homogeneous sky conditions

and iii) the generic character of the questions on *preferences*.

To improve the procedure, Q-AR was amended in: i) use of simpler and more effective data collection procedure, including a limited use of open answers; ii) introduction of respondents' subjective appraisals to describe the daylighting in a space (e.g. daylight quantity, view to the outside, position in relation to the windows) in replacement of measures; iii) more in-depth questions on cultural issues, daylighting tools and educational training.

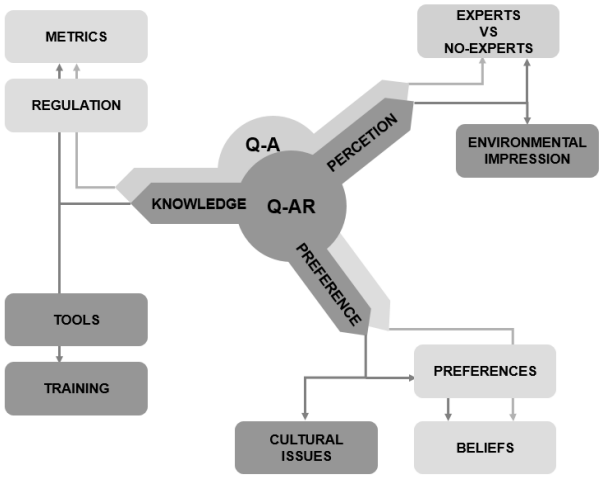

Figure 2: Expansion of the investigation areas from Q-A (light grey) to Q-AR (dark grey).

Definition of a new research goal

A new research objective was defined based on trends T2 and T4 from Q-A (see 3.1). Given the complexity of T1 and T3 findings, their analysis will be the subject of a dedicated publication.

According to T2, there was not a noticeable difference in daylighting perception between the experts and non-experts. The level of daylighting knowledge (trend T4) was low among the non-expert respondents. It hence appears that the perception of daylighting is not influenced by knowledge on the subject. To investigate this issue further, the following main changes were implemented in Q-AR (Fig. 2).

- The *perception* section was extended with a new part called *environmental impression*, to obtain subjective information about the weather, users' comfort within the space, perceived environmental comfort and occupants' mood.
- New questions about educational programmes and training were added in the *preferences* and *knowledge* sections.

Structure of Q-AR

The new questionnaire Q-AR follows the structure of Q-A's with three sections but introduces the revised content and different assessment scales (Fig. 2). The additions are:

- *Perception:* a set of multiple choice answers (*environmental impression*) and a list of 5-point unipolar and bipolar scales (*daylight perception*). The 5-point scale was used to assess participants' mood, impressions about the weather, location and daylight conditions in the classroom, e.g. «The daylight control by shading system is: (1) very low to (5) very high» or «Obstructions out of the windows are: (1) absent to (5) very high. This section was filled out simultaneously by experts and non-experts.
- *Preference*: sets of multiple answers designed to investigate preferences, beliefs and cultural issues.
- *Knowledge*: sets of multiple answers designed to investigate the knowledge on metrics and standards, and the use of design tools and regulations.

The participants' socio-demographic and daylighting education information are also collected.

4. Q-AR RESULTS FROM THE SPRING SESSION

The questionnaire was filled by undergraduate and graduate students during their lectures, through an online platform. Consistently with the new research goal (see 3.2), the data regarding the relationship between *perception* and *knowledge* was analysed using descriptive statistics.

4.1 Perception I: Environmental impression

This section aims at understanding how daylight/sky conditions and respondents' proximity to the windows may influence their general impression of a space as well as their mood.

Weather and mood

The analyses showed that higher scores of perceived comfort (visual and thermal) corresponded to sunny sky conditions (Fig. 3). However, this trend does not seem to match a similar growth of good mood (*positive* and *very positive*) (Fig.4).

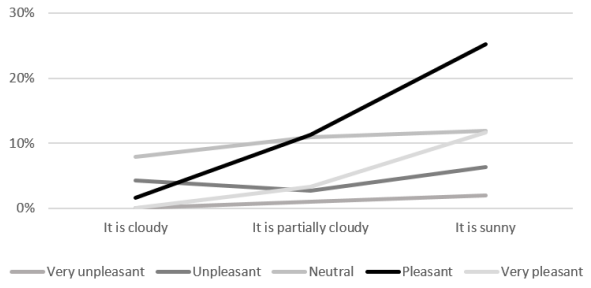

Figure 3: Comparison between weather (Question: «What is the weather like?») and comfort («For your comfort related to daylighting (visual and thermal), how do you describe the weather?»).

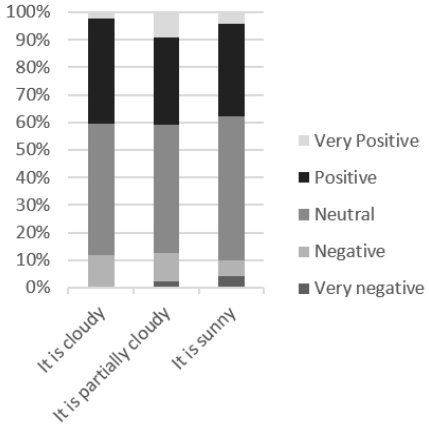

Figure 4: Comparison between weather conditions (Question as in Fig.3) and mood («Please describe your current mood»).

Comfort and position within the space

A change of comfort related to the users' sitting position in relation to the windows was noted (Fig. 5). The main findings were:

- the respondents who expressed higher comfort (from *neutral* to v*ery pleasant*) were close to the windows (*neither near, neither far* or *close*).
- more than 1/3 of students who were sitting *far away* from the windows described their comfort as *unpleasant.*

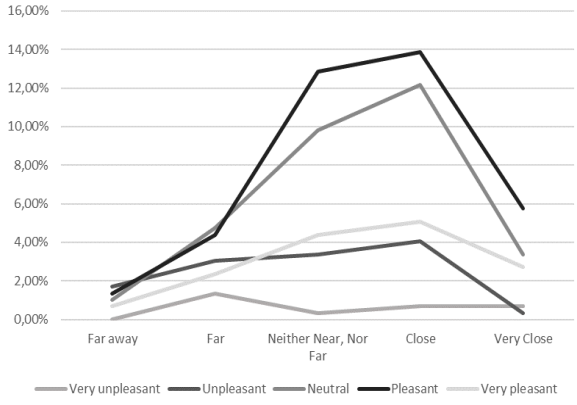

Figure 5: Comparison between comfort (question as in Fig. 3) and position in relation to the windows («What is your position in relation to the window/s?»).

Comfort and mood in relation to the weather

The data analysis highlighted two main tendencies (Fig. 6). The findings were:

- almost half (45%) of the respondents who reported a condition of *unpleasant comfort,* have simultaneously declared a *negative* or *very negative mood*;
- more than 2/3 of the respondents that reported *very pleasant* comfort, have simultaneously declared a *positive* or *very positive* mood.

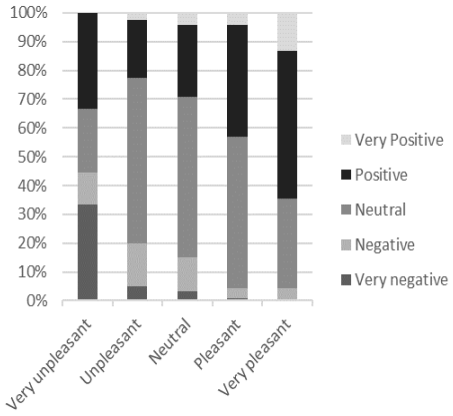

Figure 6: Comparison between comfort and mood (questions are reported in captions of previous figures).

Sitting position and mood

By cross-examining the data on position and mood, the following trends were observed (Fig. 7):

- more than 1/3 of the respondents who were sitting *far away* from the windows reported *negative* or v*ery negative mood*;
- almost 1/2 of the respondents who were sitting in a *very close* position to the windows declared a *positive* or a *very positive mood*;
- the lowest scores on mood (*negative* or *very negative*) were reported by respondents who were sitting close to the windows;
- there was not a single *(very) negative* mood for positions *very close* to the windows.

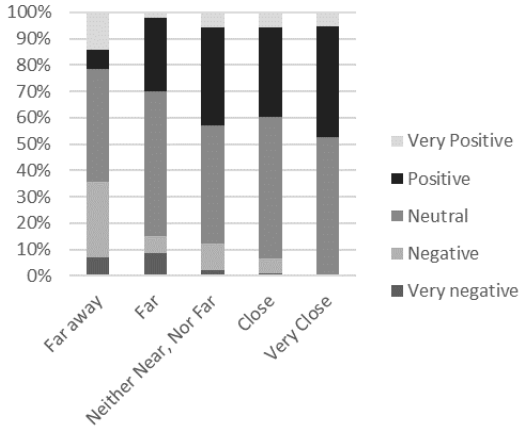

Figure 7: Comparison between position and mood (questions as in previous figures).

4.2 Perception II: Experts versus Non-Experts

For the explicit investigation of the objective defined for QA-R (see 3.2), four macro-categories concerning key aspects of daylighting were defined: i) amount of daylight, ii) quality of daylighting, iii) quality of the view out and iv) quality of windows. Each category includes several sub-topics, or indicators as shown in Fig. 8.

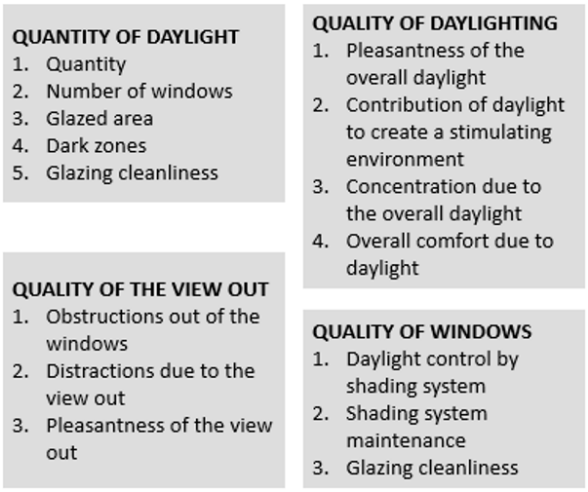

Figure 8: The selected macro-categories to analyse the Q-AR research goal in perception II section.

The judgments expressed by non-experts and experts were found to be in good agreement with regard to the *quantity of daylight*, *quality of the windows* and *quality of view out* (fig. 9a-9c). However, the *quality of daylighting* was judged as being higher by the non-experts than by the experts, for all the investigated indicators (Fig. 9d).

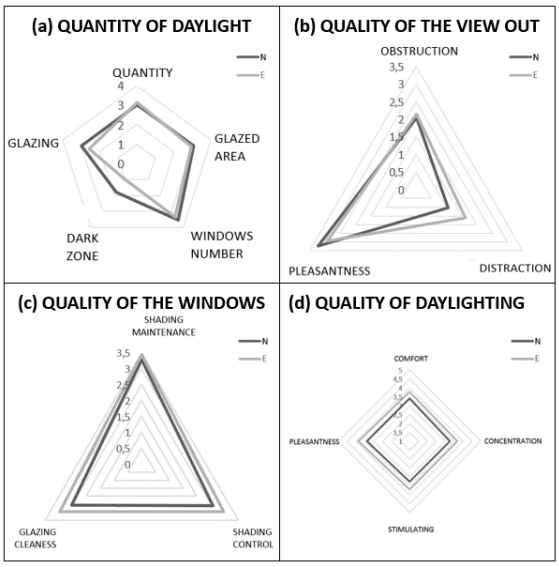

Figure 9: Comparison between experts (E) and non-experts (N) on: quantity of daylight (a); quality of the view out (b); quality of the windows (c); quality of daylighting (d).

4.3 Knowledge and Training

Although over half of the students declared to know one or more daylighting metrics or indicators, only 1/5 of them used such metrics in their projects. The number of students who reported to use computer software for daylighting modelling and calculation was greater (1/4) than those who worked on a project that involved daylighting assessment (Table 1). Only 10% of respondents knew about European regulations concerning daylighting, while 16% declared to know national daylighting standards. Only 7% of the students knew other regulations (e.g. building, energy efficiency) that included daylighting, solar gain and/or shading system recommendations (Table 2).

Over 67% of respondents attended classes on daylighting analysis and/or calculations during their studies. Less than 6% of them participated in extra-curricular lectures on daylighting subjects (Table 3).

Table 1: Students' declared knowledge on daylighting metrics, their use in design projects and the use of software for daylighting modelling and calculation.

Topic	YES	NO	No answer
METRICS	**54.5%**	43.6%	1.9%
PROJECTS	**20.3%**	76.5%	3.2%
SOFTWARE	**25.5%**	73.8%	0.7%

Table 2: Students' declared knowledge of EU, national and other regulations regarding daylighting.

Regulation	YES	NO	No answer
EUROPEAN	**10.0%**	90.0%	0.0%
NATIONAL	**16.2%**	83.8%	0.0%
OTHERS	**7.4%**	92.6%	0.0%

Table 3: Students who declared participation in classes addressing-daylighting analysis and/or calculations.

Classes	YES	NO	No answer
REGULAR	**68.4%**	31.6%	0.0%
EXTRA	**5.7%**	94.3%	0.0%

5. DISCUSSION

The following considerations may be derived from the results of the present study and in comparison to the findings of the earlier survey [8].

Environmental impression and mood

The highest appraisals of comfort (related to daylight) by the respondents occurred in the presence of sunny skies. However, a relevant relation between weather and mood was not detected, while. a good relation was detected between high levels of comfort and the proximity to the windows. This trend was observed for positions close to the window but not for positions very close to the window.

Similarly to other research [10,11], a relevant correlation between very positive and positive moods and comfort (due to daylight) was detected. The worst mood reports (negative and very negative) occurred in positions far away from the windows.

Congruence of judgments on *perception*

The congruence of judgements between experts and non-experts on the environmental perception seems to demonstrate that the interpretation regarding the quantity of daylighting is similar for the two groups. The more negative judgments expressed by the students

regarding daylighting quality can be interpreted in two ways:

- The experts were able to detect subtle aspects of comfort more easily; this seems to lead them to more positive judgments regarding the quality of daylighting (*pleasantness, stimulation, concentration, overall comfort*).
- The students had a more difficult visual (and cognitive) task to perform, this leading to higher expectations regarding the lighting.

These observations need to be further confirmed by more in-depth studies.

Knowledge and Training

67% of the interviewed students declared to have received lectures on daylighting and stated to know at least one daylighting indicator or metric. However, only 25% of them had used daylighting modelling and calculation tools in their projects Such a lack of knowledge regarding norms and requirements may therefore lead to a limited implementation of daylighting in a practical architectural design process, or to non-conscious design strategies, which do not exploit the potential of daylighting the daylighting skills learned in class seem to remain at a theoretical stage and with limited implementation in the design process.

Verification of the new goal research

Although the basis of investigation for *perception* skills was extended and refined, the first findings of Q-AR seem to confirm the trends that have been observed in the earlier Q-A survey (tendency T2). In short, during this new investigation it was noted that: i) there are similarities regarding the evaluations expressed by experts and non-experts and ii) there is a low level of daylighting knowledge and use of daylighting skills. Both trends are in line with findings from Q-A. Hence, the assumption that the perception is not influenced by individual knowledge on this matter, seems to be confirmed.

6. CONCLUSIONS

So far, the new DAYKE survey has shown 3 main trends:

1. It seems that the mood related to daylight depends on the direct benefit (comfort or sitting position) rather than on its simple presence.
2. The congruence between the judgments of the experts and non-experts, already observed in the earlier study, seems to be confirmed, except for the quality of daylighting, which deserves further study.
3. In comparison to the previous survey, a better understanding of the students regarding daylighting was noted. However, it is noted that there is still a significant lack of general knowledge regarding metrics and regulations.

7. FUTURE STEPS

The Q-AR survey data collection and analysis is an undergoing process. The findings from Q-A helped to reconsider the methodology and to define a standard protocol for future research stages (Q-AR).

The gathered data so far highlight the need for improvement of current daylighting education. The specific aspects of that education are in part dependent on professional requirements and practice. Studies involving architecture professionals are currently being planned (DAYKE stage 2).

It is hoped that the results from the DAYKE project will provide a better understanding regarding daylighting design education and practice in Europe. The obtained data should help to formulate a set of recommendations for improvement and better knowledge exchange platforms between European countries.

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