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# Lighting education for architects, the barriers and challenges: a survey of architecture students

**Natalia Sokół & Justyna Martyniuk-Pęczek**

Gdańsk University of Technology
Gdańsk, Poland

ABSTRACT: Creating a well-lit environment requires the understanding of daylight and electric lighting design principles within the built environment. Recent years have brought a large number of new lighting assessment and design methods. The discovery of new photoreceptor cells in the eye - photosensitive retinal ganglion cells - forced lighting researchers to focus on parametrisation for the image forming (IF) and non-image forming (NIF) effects of light. This triggered the re-evaluation and redefinition of an occupant's requirements for lighting. This brought a challenge as to how to introduce novel lighting concepts into practice. A survey-based study involving 140 architecture students focused on the challenges and barriers to daylight education. In this article are presented selected results of the survey from three different universities in Poland. The results indicate that one barrier to lighting education is a lack of knowledge about contemporary daylight assessment methods and that changes are needed to bridge gaps in daylight education for architects.

## INTRODUCTION

Light defines spaces. Constantly changing daylight facilitates the vision, changes perception, influences circadian rhythm, moods and affects the quality of life within a built environment. After the fascination with electric lighting over daylighting came a realisation that daylight is vital for productive work and life. The research showed that full spectrum daylight with its changing composition and varied illuminances significantly impacted cognitive performance and the circadian rhythm of humans [1]. Extensive studies on the influence of daylight on biological and psychological aspects of human life produced more sophisticated knowledge about human behaviour within the lit built environment [2].

The role of daylight design is essential to create healthy, energy-efficient and smart lighting environments. Therefore, daylight started to be considered a driving force that could help to rethink the way the urban environment is designed. Moreover, a better understanding of how lighting impacts architecture can reshape cities and create healthier and more energy-efficient places to live.

The opportunities, challenges and responsibilities associated with lighting education are the agenda of the newly established CIE Technical Committee on Lighting Education (that is, the International Commission on Illumination or Commission Internationale de l'Eclairage); the International Energy Agency Subtask 61; the Daylight Academy Educational Group and the efforts of national lighting societies. Also, the United Nations General Assembly Committee proclaimed the year of 2015 as the *International Year of Light and Light-Based Technologies* (IYL). The aim was to raise awareness of how lighting technologies can promote sustainable development and provide solutions to global challenges in energy, education, agriculture, communications and health. *The goal of IYL 2015 was to highlight to the citizens of the world the importance of light and optical technologies in their lives, for their futures and the development of society* [3].

In 2017, the international survey DAY.KE (DAYlight education and knowledge in Europe) investigated daylight education deficiencies among graduate and undergraduate architecture students [4]. The study involved about 600 students from seven countries. Selected results on barriers and challenges are presented in this article from a pre-DAY.KE-survey conducted of 140 Polish students.

## CHANGING COMPREHENSION OF DAYLIGHT WITHIN THE BUILT ENVIRONMENT

The role of daylight in creating a built environment in the pre-electric area was undeniable. The symbolism of light is a part of the cultural heritage and was often a motivation for architectural design (ancient sanctuaries, Roman villas, public baths, gothic or baroque churches) or art (chiaroscuro and tenebrism in baroque paintings). Throughout the centuries, the role of light in creating architecture was a subject in many guidebooks for architectural adepts and philosophical treatises illustrating the multidisciplinary character of daylight comprehension. The 21st Century is the era of the Internet, solid-state lighting, 24-hour city life, energy efficiency and bionic architecture. Electric lighting enables people to be active after dark and prolongs working hours. The low illuminances and energy-consuming light sources were phased out and replaced by powerful, highly efficient lamps.

Humans' ambiguous reaction to prolonged exposure to a high level of artificial illumination with a high content from the blue spectrum triggered studies into circadian neurobiology [2]. These studies proved the advantages of the natural light-dark cycle over artificial light [1][5]. Recent attempts to interpret non-image forming (NIF) effects of light and to combine them with building information modelling (BIM) through computer-aided design (CAD) to create spaces customised to human biological and psychological needs, illustrate a trend of human-oriented holistic lighting design.

In architecture, the main emphasis was put on ways to provide daylight into the building and the means to control it. The daylight consideration is present during design decisions about location and orientation, the form of a building, avoidance of external obstructions, the spacing between buildings, and the position and size of daylight apertures. The foremost factors that determine the levels of daylight are:

- latitude, sunlight probability, obstruction, building shape and layout (urban level);
- fenestration size and location: the ratio of glazing areas to floor space (room level);
- façade design, window-to-wall area ratio (WWR);
- glass transmittance and reflectance factors LT (light transmittance) and LR (light reflectance);
- design of shading systems;
- daylight-optimised interior design;
- daylight-responsive electric lighting controls.

The main challenge of daylight is its variety. Daylight availability varies in both the amount and spectrum depending on the season of the year, nature of the cloud cover and predictability of the weather conditions, geographical location, size and location of the windows or roof lights, obstructions outside the building, transparency of the glazing and a shading system. Therefore, the daylight effects and installation have to be considered and integrated into the building fabric in the very early stages of the architectural design. The daylighting design objectives are:

- provision of the right amount of good quality sunlight and skylight to ensure proper visual effect;
- the well-being of residents and reduction of electricity demand;
- avoiding undesirable side effects.

Daylight conditions and availability can change rapidly because of the weather, and it may affect the moods of the occupants of a building. The main challenges of daylighting include:

- glare control;
- reducing reflections, reduction of contrast between the light entering the building and the light on the internal surfaces;
- an avoidance of overheating in the summer and heat loss from windows on cold days (energy efficiency);
- prevention of luminance distribution and variety of brightness.

Windows are the source of daylight luminance and views. The view is demanded by the residents providing connectivity with the outside world and giving information about outdoor surroundings and the time of day. However, people will take action, including the use of shades to reduce daylight, if it causes a visual or thermal discomfort. Frequent exposure to sunlight outdoors can cause tissue damage. Indoors light is filtered by the windows, but still can have a negative effect on people with extra sensitivity to ultraviolet radiation. The costs of daylight solutions, usage and maintenance have to be evaluated from the start. Therefore, other challenges are; for example, financial efficiency of implemented daylight solutions.

Further implementations include:

- integration of daylighting design into all design stages based on the contribution of daylight knowledge to the design and construction;
- counteraction against shading by obstruction including obstruction from trees, other buildings or terrain;
- daylight holistic comprehension by design decision-makers.

The contemporary comprehension of daylight and its relation to humans' cognitive performance and health forces architects to require adequate training in modern daylight design techniques.

## LIGHTING TRAINING

The complexity of architectural training is well captured in Vitruvius' treatise, *De Architectura: architecture is the science arising out from many others sciences and adorned with much and varied learning* [6]. An ability to create well-lit spaces requires a range of theoretical lighting knowledge, practical design solutions and experience (see Figure 1).

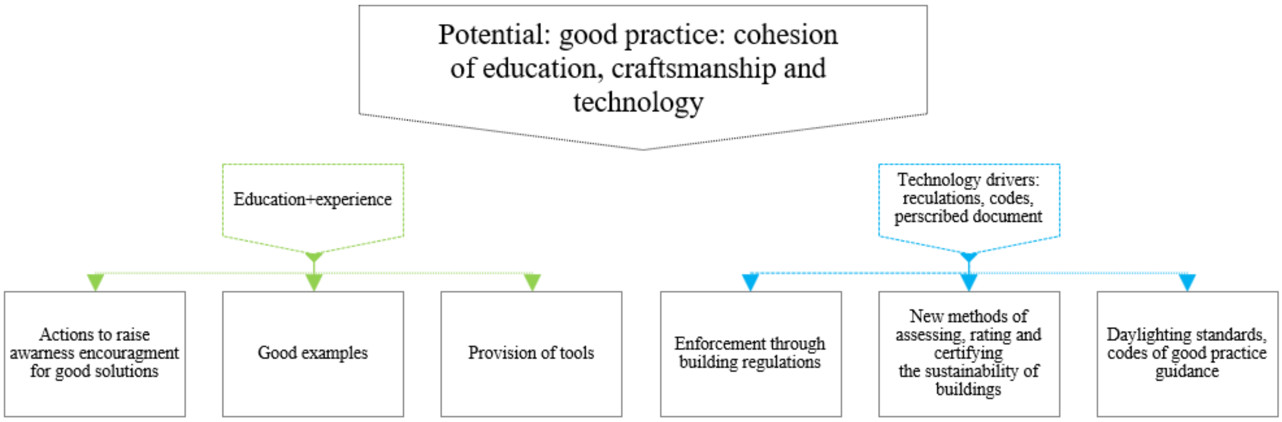


Figure 1: Good practice in lighting education.

Throughout architectural history, daylight design was an integrated part of architecture planning and the results of the architect's ability to envision buildings in daylight. The current studies of daylight within a building focus more on the energy efficiency and non-visual responses to light. A number of researches suggest light-related design solutions may impact the health, well-being and productivity of building residents. Lighting societies recommend that lighting studies should be offered as a part of architectural training. However, the challenge is to determine the content of lighting education training.

Despite intensive research on how daylight is bound up with human vision, psychophysiology and health, there are still insufficient data to determine criteria for daylight within the built environment. To define and standardise these criteria is one of the challenges for lighting education. The present mandatory daylight recommendations for the built environment are often unsatisfactory, but they are meant to support good practices to ensure minimally acceptable conditions [7]. Yet despite constant improvement of the daylight criteria, tools and recommendations, these tools do not assure reasonable design solutions, which come from the architect's knowledge, craftsmanship, experience and intuition.

The new metrics for daylight and daylight appraisal computational tools can overwhelm and confuse an architect. Reinhart and Fitz, while surveying architects and engineers on the use of daylight simulation in building design, found that just 51 out of 185 respondents used computer simulations for daylight analysis [8]. The data collection took place in 2003 and 2004; therefore, these results could be outdated. However, the study indicated that among those who claimed employed computer simulation tools for daylighting design, 42 different simulation programs were mentioned. This illustrates the challenges faced by the lighting community in unifying and delivering fewer, but more comprehensive daylight design tools for architects.

## LIGHTING EDUCATION WITHIN ARCHITECTURAL CURRICULA

The development of new technologies and knowledge and their use within architectural design requires interdisciplinary skills and specialist knowledge; for example, in the field of lighting technology [9][10]. The curricula of undergraduate and graduate architectural courses at 34 public and private universities and technical schools in Poland illustrate that there are not many lighting classes. Daylighting lectures sometimes are offered as supplementary courses or as optional classes.

Among the top five universities (with the highest grade ranking according to The Polish Accreditation Committee (PKA)) offering the BSc and MSc in architecture to 7,111 students (2016), only one offered 60+ hours of mandatory advanced lighting course with ECTS credits. However, the daylighting and lighting-related subject, may be discussed during building physics courses or elective studios. Furthermore, the specialised courses on sunlight evaluation (sun diagrams) are from time to time offered by local chambers of architects or sunlight simulation software companies.

## POLISH ARCHITECTURE STUDENTS' DAYLIGHT DESIGN KNOWLEDGE: A SURVEY

The 140 architecture undergraduate students from three top universities in Poland completed an on-line daylight questionnaire. The questionnaire examined their ability to assess daylight conditions within a given space; their knowledge of daylight metrics, assessment methods and regulations; and their daylight preferences. The specific aim was to establish among the group the gaps, challenges and barriers to daylight comprehension. The goals of the survey were to:

1. Identify possible gaps in daylight education.
2. Understand the kind of additional training needed to prepare future architects for integrating daylight design into their design practice.
3. Advise on the content of the necessary daylight curricula for architectural training to address the educational gaps.

Results

All 140 participants provided statistical information about themselves. Participants numbering 112 assessed the daylight conditions within a chosen space and 86 answered the knowledge questions. All the lighting terms identified by the participants as unknown or ambiguous (such as daylight glare, uniformity, veiling reflections) were explained through textbooks.

During the evaluation of daylight conditions within a space (see Figure 2) just 41% of respondents were able to name the daylight appraisal methods. Just 34% of architecture students were able to name any of the known daylighting indicators.

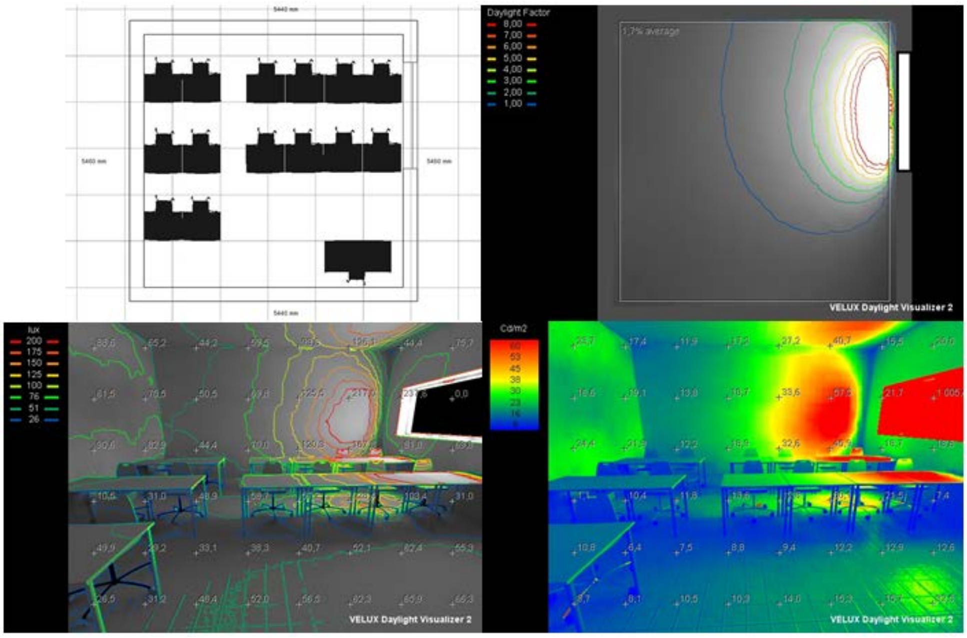


Figure 2: Simulation of daylight conditions, where students did questionnaires (date 21.05, noon, intermediate sky: CIE-7, average daylight factor 1.7, illuminance levels on the desks below 500 lx, luminance below 60 cd/m$^2$, software Daylight Visualizer 2).

Almost 64% of respondents could not name any daylight regulation. Just 10% of respondents had participated in a project where daylight design methods had been applied. Another 32% of students had brief knowledge that daylight was mentioned in Polish building standards (see Figure 3).

The survey results demonstrated that, although there was an awareness of daylight design methods, a general lack of knowledge on this subject was noticeable. Furthermore, more than half (53%) of respondents could not indicate an example of an implementation of good daylight strategies in architectural planning. However, half of the participants welcomed education on daylight design metrics, regulations and solutions.

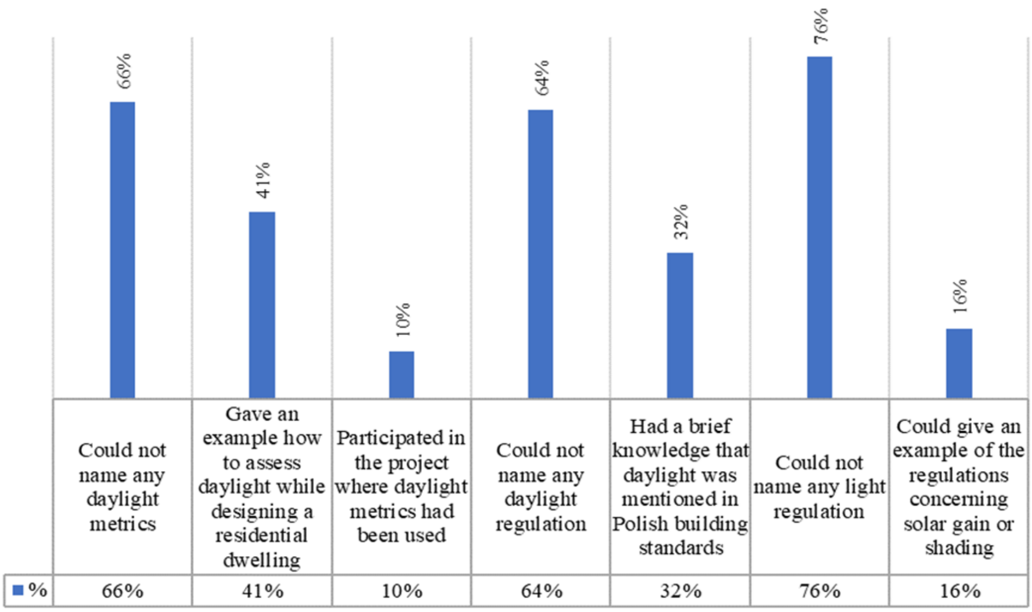


Figure 3: Selected results of the knowledge survey (Metrics and regulation knowledge).

The survey results indicated gaps in architectural training in relation to knowledge of:

- contemporary metrics;
- contemporary assessment methods and tools;
- daylight guidance existing in building and lighting regulations.

## BARRIERS AND CHALLENGES

Despite the shortcomings in the research instruments, especially the reliability of the survey (small group of respondents), analysis of the results indicates there exist some significant challenges and barriers for daylight education for architectural students.

The literature review identified that one of the challenges for modern daylight education in Poland is the limited number of publications, especially those dedicated to daylight comprehension within the built environment. One of the identified barriers for better education was a lack of daylight textbooks in Polish.

The results of the questionnaire may indicate that daylight education for architects in Poland does not tackle contemporary daylight metrics nor prepare students to carry out daylight appraisals. There is a significantly little coverage of these issues in architectural curricula offered even by the top architectural universities. The survey results show the general lack of knowledge on daylight metrics, assessment tools and regulations among architecture students, which may indicate a lack of proper training.

The identified barriers are:

- a limited amount of research about contemporary daylight design techniques (literature review);
- the low awareness of modern daylight indicators among future architects (survey);
- few national initiatives promoting daylight design as a sustainable design approach (literature review);
- low quality of design solutions, which may be an effect of gaps in cross-discipline education (literature review, survey).

## CONCLUSIONS

A great need exists to inform professionals engaged in the built environment about the latest findings of daylighting. Some assessment methods based on new daylight indicators may be confusing for an architecture practitioner. A recognition exists in the literature that there is a relationship between daylight and buildings and that better comprehension of their interdependences contributes to design, which affects inhabitants' lives [11].

There is a lack of daylight metrics taught to architects. The survey results indicate there is a need for new educational frameworks in Poland to include modern daylight evaluation methods. A fragmentary daylight education among architecture students may affect their understanding of daylight qualities. This fact may be a major barrier to the development of a sustainable built environment and is a significant challenge.

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