# Uncharted territory: daylight performance and occupant behaviour in a live classroom environment

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In 2013, in an effort to improve the visual environment in future schools, a UK regulation specified mandatory daylight evaluations using, for the first time, climate-based metrics. Existing research on the daylighting performance of classrooms is limited and challenged by poor light measurement instrumentation, as well as the practicalities of the 'live' classroom setting. This paper describes an ongoing project aimed at providing evidence that will improve the understanding of how building occupants perceive daylight; how they respond to daylight performance due to the building design; and how their needs and actions shape the actual daylight performance of classrooms. A mixed method qualitative and quantitative approach is presented for the investigation of the aforementioned in four classrooms located in two secondary schools in the UK. Previously mentioned challenges are addressed by employing a High Dynamic Range imaging technique for monitoring physical data and the behaviour (blind and electric light use) of the occupants. The challenges encountered in the current study are discussed.

## Introduction

The latest government directive on daylight design for schools [1] provides the context for this research project. It is a document produced in 2013 by the Priority Schools Building Programme (PSBP) on behalf of the Education Funding Agency (EFA) that includes mandatory daylight requirements for classrooms. Its particular significance lies in the fact that it is the first policy document to use the relatively new climate-based daylight modelling (CBDM) metrics, abandoning the traditionally and internationally used Daylight Factor (DF) for daylight performance evaluation indoors. Undoubtedly this shift aims to improve the luminous environment of classrooms for the benefit of the building occupants. However, does the existing knowledge on daylight performance and users' perception of daylight allow for the appraisal of daylighting recommendations, whether they be founded on CBDM or the daylight factor?

Previous research on classroom daylight levels focuses on the intrinsic daylight performance of spaces due to the building shell and fixed design elements [2,3]. However, the luminous environment results from the operational performance of the space as shaped by the occupants (e.g. blinds usage) and their needs. Efforts to investigate the latter have been scarce [4] and challenged by: the limitations of existing measurement instrumentation to collect physical data that corresponds to the complexity and variability of daylight over time [5]; and the limited tolerance of live classroom environments to acoustic and other intrusions.

Thus, a gap is identified in the understanding of: how classroom users perceive daylight; how they respond to the intrinsic daylight performance of the space; and how their needs and actions shape the operational daylight performance over time. In terms of user needs, this gap is currently further pronounced by changes in teaching methods and means that have taken place over the last decade, which resulted in a reliance on Visual Display Technologies such as smart-boards and tablets, and consequently in new visual needs for modern classroom users.

The overarching aim of this project is to explore the extent to which UK government daylight directives result in classrooms that satisfy the lighting needs of the users. A mixed method approach is taken in order to provide evidence that supports answers to the aforementioned points in the case of four classrooms in two UK schools. Data collection in these spaces is currently ongoing.

## Methodology

The methodology followed is based on High Dynamic Range (HDR) imaging. HDR produces images where each pixel is a reliable measurement of scene luminance at that point in the space [3,6,7]. Employing HDR photography as a monitoring tool facilitates the quantitative as well as qualitative aspects of the study by tackling some of the main challenges previous studies have encountered. More specifically, the advantage of this method is that it enables the non-intrusive collection of physical data, as well as the observation of user behaviour, over extended periods of time, rendering it suitable for education environments. In more detail and regarding the former point, it allows the simultaneous measurement of luminance in multiple (as many as the number of pixels) points of a scene (Fig. 1).

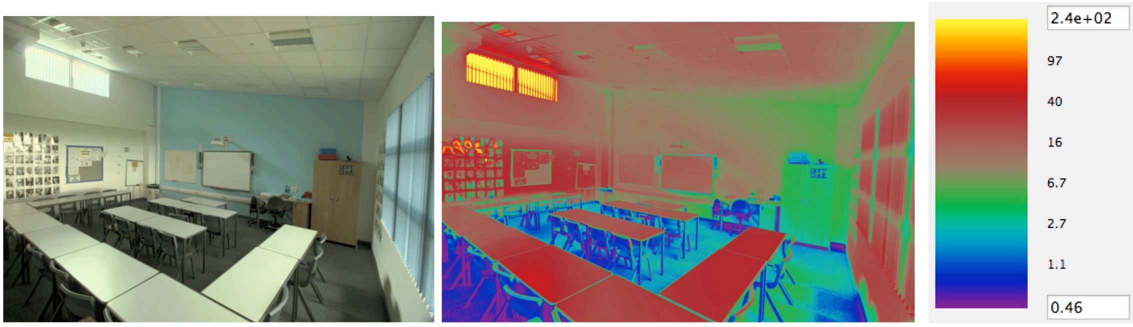


**Figure 1. HDR image of a case study classroom:** with false colour image, mapping luminance values

The set up (Fig. 2) installed in each of the four classrooms comprises a DSLR camera with wide-angle lens, connected to a computer processor running the 'gphoto2' camera control software [8] for the photos' automatic capture, compilation and collection. HDR photos are taken every 10 minutes, daily from 8am to 6pm, from April until mid December 2015. External sunshine data is simultaneously collected within a kilometre of one of the schools and 15km of the other. The classroom selection provides a variety of floor and window area, aspect, orientation, view obstruction and window shading.

**Figure 2. Monitoring set-up:**

Blimp encasing a DSLR camera and wide angle lens; computer processor; connecting cables; safety locks, chains and fittings accompanied by a notice for contact information and handling.

The subjective responses of approximately 120 occupants are sought by means of the Grounded Theory Method (GTM). GTM is a research methodology used in the social sciences for the past three decades which allows the outcomes to emerge from the data using a systematic procedure. Data collection involves initial interviews with staff as a precursor to a 20-question questionnaire addressed to students and tailored to each classroom. Parallel manual analysis of the HDR photos enables triangulation of the qualitative data collected, for example, the amount of hours of projector or laptop weekly use in class, use of blinds or lights, etc. Lastly, focus groups with users explore the rationale behind patterns that emerge from the questionnaire data and actions observed in the several months' worth of photos. This phase ends in early 2016.

The analysis aims to identify visual needs, as well as the association between the users' characterisation of daylight and the measured daylight performance for the four classrooms. Additionally, it will enable comparison between the latter and predicted daylight performance based on pre-2013 and post-2013 daylight assessment metrics. Finally, findings from a parallel Loughborough University project, investigating modelling practices involving CBDM based daylight evaluation, will add the simulation predicted dimension to the comparison [9].

## Challenges and Lessons Learnt

One of the inherent challenges of the mixed method approach is that projects that adopt it often confront issues relating to both the quantitative and qualitative spheres, e.g. lightning storm corrupting external data monitoring capture for the former, and. participants altering their decision to participate for the latter. This demands, firstly that the researcher operates and shifts between the mindset of both types of research methods, and secondly that time is carefully allocated to accommodate learning of tools and acquiring skills applicable to both spheres. Ensuring that all ethics requirements are met is a task that also needs careful planning since it directly involves busy school staff, minors and, indirectly, their guardians. The importance of maintaining good communication links with all school stakeholders cannot be emphasized enough, as their months-long commitment is vital to the project. The presence of a school 'project champion' can also make a big difference in the time and effort dedicated to data collection, as well as the size of the participant sample.

In practical terms, due to the fact that a single HDR photo is a large (~50MB) file, the management of multiple terabytes of HDR data adds a degree of difficulty. Also, software used for image processing and viewing is often specific to a computer operating system and camera models, hence interoperability of software tools has to be factored into the equipment selection. In monitoring a live classroom environment, the shutter noise of a camera can deter teachers from agreeing to participate in the study, thus camera silencing devices, such as a 'blimp' may be used to overcome the problem. Lastly, mechanisms to discourage vandalism or theft of the monitoring equipment, a reality of secondary schools in particular, form an important planning and budget consideration.

## Summary

This short paper has highlighted the need for a better understanding of the users' needs and perceptions of daylight in order to produce the insights and evidence that might improve the design and evaluation of the luminous environment in modern classrooms. Moreover, it has described the mixed method approach followed by an ongoing project aimed at providing evidence toward addressing this gap, as well as some of the challenges and issues encountered. It is hoped that this presentation of the HDR technique for measuring actual daylight performance of classrooms in use will encourage further investigations into this formerly uncharted territory.

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