Artificial Lighting Design for Primary Learning Environments

A study on the effect of non-uniform distribution of artificial light on pupil behaviour during class

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The author of this work, Imke Wies van Mil, is an educated, professional architectural lighting designer with an interest to investigate how artificial lighting could be applied in contemporary educational environments to benefit pupils learning. The project concerns an industrial PhD and has been conducted in collaboration with architectural practice Henning Larsen and the Royal Danish Academy - Architecture, Design, Conservation.

The context of the research is Denmark's system for primary and lower secondary education, or *Folkeskole*, which underwent a significant pedagogical reform in 2014. The reform amongst others called for improved conditions for undisturbed learning. Those conditions were found most pertinent during so called focussed-learning activities such as mathematics and reading practice, during which pupils need to concentrate on a task that requires their sustained attention. Research found that disturbances during class are predominantly caused by pupils themselves, and a typical manifestation thereof is noise.

Fields studies in three contemporary school buildings, undertaken in the first phase of this project, evidenced the common approach by school designers thus far is to mitigate the impact of noise, for example by applying sound absorbing materials. However, an arguably more effective approach could be to prevent (noise) disturbances caused by pupils from occurring. Typically, disruptive behaviour is addressed by teachers through various management techniques which predominantly rely on interaction between teachers and pupils. But the physical learning environment itself may also yield potential as research evidenced various environmental features, including the indoor climate variables light, sound, temperature and air quality, have the capacity to influence occupant behaviour. This knowledge provides prospects for school designers looking to address the need to improve the environmental conditions for undisturbed learning.

This research investigates the potential of one particular environmental feature, namely that of the artificial lighting, to address the issue of disruptive pupil behaviour. Research from amongst others the fields of lighting science and environmental psychology established that artificial light has an impact beyond making things visible in the learning space. Artificial light has for example also been found to bring about change in pupil's mood, motivation, and social interactions, which in turn have been found to affect pupil's behaviour and learning performance. This research seeks to explore if and how artificial lighting could be specifically utilized to decrease disturbances created by pupils during focussed-learning activities, and herewith improve the conditions for the pupils to concentrate on their educational task and ultimately, better their learning performance.

In order to gather evidence for this position, a field experiment was developed that assessed the implications of two different artificial lighting conditions on the behaviour and learning performance of circa 200 pupils aged between six and twelve years old. Hereto an experimental lighting intervention was designed and implemented in four learning spaces of the newly built Frederiksbjerg school in Aarhus (DK). The electrical lighting system installed allowed to exposure pupils (and their teachers) to two significantly different artificial lighting conditions: (A) the standard uniform light condition typically found in today's primary learning spaces, and (B) a specifically designed non-uniform pools-of-light condition. The uniform condition typically refers to a relatively equal distribution of light across a space, while a non-uniform light conditions refers to non-equal distribution of light, and typically features brighter and darker areas across the space. In order to avoid compromising pupils' learning and teaching processes, the setup of the lighting installation was non-prescriptive and allowed teachers (and pupils) to select a light condition considered most suitable for their activity at any moment in time.

The experiment took place during several continuous weeks in the Spring and Autumn semester of 2017, and followed a crossover research design that allowed to expose the pupils partaking in the experiment to both artificial light conditions whilst continuing their normal curricular routines and activities. During these exposures, change in pupils' behaviour and learning performance was assessed by monitoring three associated variables: noise levels during class, three typical observable disruptive behaviours, and pupils' cognitive performance. To lower the risk of data contamination, fourteen additional environmental conditions were monitored or measured too.

Analysis of the different data sets suggests that the use of the experimental lighting installation, and the pools-of-light condition in particular, led to improved conditions for pupil's learning. Less occurrences of disruptions caused by pupils (which divert pupils' attention away from their learning task) were observed during focussed-learning activities when the pools-of-light condition was activated, and pupil's performance on a focussed learning task modestly improved. This outcome implies that a lighting design that allows for variation in the artificial light condition in the learning space, benefits learning outcomes. This finding is further supported by the decision of Frederiksbjerg school to make the temporary lighting intervention permanent, and to install similar interventions in other learning spaces too.