Meaningful Defragmentation. Engaging design research strategies in the education and practice of architectural lighting.

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MAIN TOPIC
Hotels

LIGHTING DESIGN
Andronikos Hotel on Mykonos/GR
The Grand Hyatt Playa del Carmen resort in Mexico
Abadía Retuerta LeDomaine in Sardón de Duero/ES
The Tuve boutique hotel in Hong Kong/CN

DESIGN PRACTICE
Design research strategies

COMPETITION
Lighting for London’s bridges
Architectural lighting is defined as a field within architecture, interior design and electrical engineering that is concerned with the design of lighting systems – daylight, electric light, or both – to serve human needs. Donoff (1) argues that architectural lighting is an act of crafting exterior or interior spaces with light, which are in concert with architecture using the appropriate knowledge, experience, and expertise. The inference here is that architectural lighting is meant to last for a substantial period of time, unlike related fields such as theatre or event lighting, which is created for a specific performance and exists only for the duration of its run. She further argues that the lighting designer disposes over a knowledge base which is very different from that of an artist or an industrial designer whose focus is on designing “decorative lamps”. An architectural lighting designer requires the know-how and skills to be able to work on both interior and exterior projects of different scales, an understanding of technical issues and the associated vocabulary, skills in the application and control of both natural and electric light, an acute understanding of the operational mechanics of luminaires, and the ability to discern the qualities of different light sources, the colour temperatures they offer and the optical systems required.

Design research refers to the scholarly inquiry that seeks to advance design by studying and improving it in systematic and scientific ways; it covers a wide range of interrelated disciplines including industrial design, design computing, interaction design, product and innovation management, engineering, architecture and interior design, and therefore by extension architectural lighting (2). Studies reveal that design research has several relevant implications in the practice of architectural lighting: research on ‘dynamic white’ electric lighting systems that can shift colour temperature in alignment with daylight paired with well daylit spaces shows improved recovery time in hospital patients (3,4); a connection has been found between mood, gender, quantity and spectral distribution of light, where women’s problem-solving skills decrease in warm light and increase under cool sources, while men’s problem-solving skills increase in warm light compared to cool light (5,6).

However, the belief that design research has little impact on practice is persistent (2). Boyce (7) argues that research plays little or no role in the design process, as designers are confident with regard to their ability, creativity and powers of judgement and seldom require inspiration from research results. Popovic (8) further argues that research has not been very common among designers because of its nature and the way that professional practice operates. Additionally, the connections between design research and practice...
have not been well defined in the realm of architectural lighting. While the traditional perspective is that research can be characterised as a linear spectrum from basic to applied, design research has no logical or natural mapping related to this spectrum (2).

All these observations lead to the following questions: How does knowledge creation and transfer relate to the definition of design research in architectural lighting? What are the modes and rates of knowledge creation and transfer in architectural lighting? Does design research need to be commercialised to be successful, or is its impact on the education of the next generation of architectural lighting practitioners more significant?

1. Method
A report (9) by the Royal Institute of British Architects [RIBA] identifies three modes of aligning research and knowledge in design practice namely: (i) knowledge – the subject of the research; (ii) process – ways of researching and finding knowledge; and (iii) resources – ways of accessing knowledge (Fig. 1). Literature reveals that research activity related to design is exploratory, and is both a way of inquiring and a way of producing new knowledge (10,11).

In this context, Popovic (12) has proposed an applied research and innovation framework that situates design research within a social structure constituting people, activity, context and culture to generate new knowledge and support innovation through the following four modes: research conducted before design commences; research conducted concurrently during the early design stage; research conducted concurrently during design development stage; research conducted when the design has been completed and the project has been realised. Defragmentation is a process used in the realm of computing to reduce the fragmentation of a file by concatenating parts stored in separate locations on a disk. Building upon this defragmentation analogy, we proposed an initial defragmentation framework (13) that concatenates this RIBA report and Popovic’s framework to arrive at three modes of incorporating design research into practice: research conducted before the design commences, research conducted concurrently during the design stage, and research conducted when the design has been realised.

However, the shortfall of this framework was that universities, corporate and governmental funding agencies recognise only three categories for approaching new design knowledge, namely (14,15):

i. Basic research – which focuses on the empirical examination of fundamental principles which can lead to developing theories about design that has far-reaching implications for the discipline

ii. Applied research – which focuses on investigating general classes of design problems or products in the form of a systematic enquiry to gather from many individual cases an hypothesis, or several hypotheses, which may explain how a class of design problems arise, and the kind of reasoning that is required to effectively solve those design problems

iii. Clinical research – which focuses on specific design problems or issues and individual cases requiring research need to be commercialised to be successful, or is its impact on the education of the next generation of architectural lighting practitioners more significant?

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2. The eventual defragmentation framework
The eventual defragmentation framework also consists of three modes, which are categorised in the following manner so as to align with the funding agencies:

i. Basic – research conducted before the design commences

ii. Applied – research conducted concurrently during the design stage, and

iii. Clinical – research conducted after the constructed design is in use / has been realised.

It is important to note that within the confines of this framework, basic research relates more to the theoretical aspects of design, while both applied and clinical research relate more to the practical aspects of design.

2.1 Basic – research conducted before the design commences
Research conducted before the design commences is a mode that acquires knowledge utilising relevant research methods to be applied when developing lighting design concepts. This mode of research is the fundamental understanding a designer needs, since it defines and frames the design.
problem while evolving concepts as reflective conversations leading towards the given project situation (11,16–19). This in turn leads to the generation of discipline-specific knowledge that may be communicated via drawings, sketches, models, and other primary visual representations embodying non-verbal codes or messages (10,11,20,21). Much of the work performed within this mode is normally categorised under the headings of other disciplines such as sociology, psychology, semiotics, economics, history of design, aesthetics and design theory, as well as the analysis of design activity (22,23). Within the scope of this mode, architectural lighting design teams can perform various activities such as literature reviews, feasibility studies, and site analysis.

2.2 Applied – research conducted concurrently during the design stage
Research conducted concurrently during the design stage is a mode that personifies research through design. This mode is unique as it is derived from and valuable for practice, and places emphasis on the research objective of creating design knowledge, not the project solution (16). The early design stage is crucial as all designs are conceptualised at this stage leading to the creation of new knowledge through an action-reflection approach (24). It encompasses analytical and critical thinking given that design teams perform tasks such as lighting calculations and 3D visualisations to critically evaluate the design. This enables the design team to identify, recall and apply the relevant knowledge required (25). During the design development stage, additional research may be required to either develop detailed lighting concepts, produce final lighting designs or site-level mock-ups to understand the impact of light. This stage may also be called project-grounded research and/or research-oriented design (22,24), and may combine the practice-based research approach of practitioners with reflection and research questions that may not be restricted to the project on which research is being conducted (23). This is the stage where the highest knowledge transfer can occur, since experts from different fields and realms may be contributing to the overall design. This form of research becomes a vehicle for acquiring and shaping know-how, which in turn can assist in future design activities (11).

2.3 Clinical – research conducted after the constructed design is in use / has been realised
Research conducted when the design concept has been implemented is a mode to evaluate the overall success of the proposed lighting design scheme as well as to explore new strategic opportunities. This mode of research conducts systemic enquiry through the medium of practical action where new or newly imported information, ideas, forms or procedures are tested to generate communicable knowledge (26). It provides information, implications, and data based on primarily prescriptive research methods for specific and feasible design solutions; designers can apply this knowledge to achieve the desired end-result in their design projects (11). Notably, this is the mode that many practitioners and academics associate with the term “Design Research”, as it has the most potential to contribute to successful design outcomes (27,28). In this mode, both quantitative and qualitative research methods may be appropriate (29). The proposed scheme can be evaluated using these methods to measure the extent to which the design succeeds in satisfying end-user needs, such as accessibility, functionality or ease

References
12. Popovic V. Applied Research and In-
of use, while also meeting project requirements such as budget, size or technical requirements (30). The research findings can be applied to generate better lit environments for the future.

3. Analysis

Three example projects of different scales and scope have been identified as case studies to validate the three different modes of applying the eventual defragmentation framework. We have been directly involved in the design and research of each of these projects from initiation to realisation.

3.1 Example 1 – Basic research: Harbour Crane

The Harbour Crane at Kotor Bay in Montenegro (Fig. 3) serves as an example of a project involving basic research. Before proposing a lighting design concept, the design team undertook an extensive site analysis of the bay, which is a UNESCO World Heritage Site. The crane being the tallest and most visible element made it the automatic choice for highlighting the history of the site (Fig. 4). However, special care had to be taken so as to cause minimal disturbance to the natural beauty of the bay and landscape by night as well as to the adjacent residential development. The challenge was therefore to develop a lighting design concept that would evoke the memory of the crane in operation while reducing light spill and associated energy consumption issues in the course of the night. A dual-scene lighting concept, represented and communicated via conceptual renderings, was proposed to the client: Early evening and late night scenes (Fig. 5a and 5b).

3.2 Example 2 – Applied research: Gedee Car Museum

The project selected to demonstrate the role of applied research is the Gedee Car Museum in Coimbatore, India (31–33). With around 70 different car models, the museum claims to be one of its kind in India. A considerable amount of research went into the design process as each car in the museum has its own history, and the underlying lighting theme had to provide a visual hierarchy based on the historical significance of these cars (Fig. 6). A detailed study of the different types of cars, a number of photometric analyses and several mock-ups later, generic lighting typologies were finally arrived at for each car size in terms of optics and colour temperature. The typologies were categorised into ‘small,’ ‘medium’ and ‘large’ cars to facilitate the legibility of their details. Track-mounted spotlights using interchangeable lens technology were used to experiment with in order to determine the optimum optics for lighting a particular car. Spot or flood optics were used for

small cars (Fig. 7), while a combination of the two was used for medium cars (Fig. 8). Oval flood optics along with spot and flood optics were applied in the case of the larger cars (Fig. 9). Any additional accentuation of certain key elements of the car, such as logos or insignia, was achieved using narrow spot optics. The pigments contained in the car paint or posters served as a basis for selecting the respective colour temperature. For example, 2700K or 3000K was used for warm tones such as red, brown or gold, while 4000K was the appropriate solution for cool tones such as blue or silver. The choice of colour temperature for neutral pigment tones, such as black or white, is based on the time when the cars were put on the market. For example, 2700K or 3000K is used for cars from an older period, while 4000K is used for cars designed in more recent years. Cars that mark either a ground-breaking paradigm shift in automobile history or any other historical event of significance were treated as 'highlight' cars. A highlight car was first provided with a general wash to recreate the time it stemmed from, using flood or oval flood optics depending upon its size. Then special features which have a certain historical significance, such as bumpers, headlights, hood, seats or wheels, were accentuated using spot or narrow spot optics. A combination of 2700K, 3000K and 4000K has been used for the special effect lighting in place of the standard typology of a single colour temperature based on pigment colours (Fig. 10).

3.3 Example 3 – Clinical research: Tangible Lighting Controls
The project example used to describe what clinical research entails is a PhD research project in architectural lighting entitled "Tangible
Lighting Controls” (34–39). The project aimed to identify end-user requirements that help improve the effectiveness of lighting control systems. The crucial question posed was, what is the nature of interface designs sought by end-users for maximising interaction with lighting control systems? A prototype interface design for lighting control that essentially works on any type of hand-held touch-screen device was developed. This interface, which is referred to as the tangible lighting control interface (Fig. 11), consists of a central image of the lit environment with respective alphanumeric cue references to the lighting layers. “1,” “2,” and “3” are displayed on the interface to provide a direct and accurate mapping of the layers of lighting and their respective controls. This is programmed to provide a synchronous gradual fade in luminous intensity and colours in the actual lighting scene when the sliders or colour controllers are used. Two sliders are allocated for controlling the luminous intensity of Layers – 1 and – 2, while a colour palette is allocated for controlling Layer – 3: a black Off button for switching off the ceiling lights and one button each for the other five colours from the test environment: amber, blue, green, red and white. Every saved scene is represented with thumbnails on a display scroll bar, and eight scenes can be saved, scrolled and recalled using the scroll bar. A prototype design based on the designs of conventional pushbutton and touch interfaces (Fig. 12) was also developed for a comparative analysis. Empirical testing using qualitative and quantitative methods was carried out where test subjects evaluated which of the two interface designs maximised end-user interactions with the lighting control system. Test results showed that the tangible lighting control interface enhanced end-users’ ability to create their desired lighting levels and mood by enabling the ease of understanding control functions and enhancing their satisfaction at being able to perform control tasks.

4. Discussion
The framework attempts to organise information found in literature, primarily to develop insights into the complex definition of design research in the realm of architectural lighting. By relating the terms – design conducted before, during, and after – to terms used by contemporary funding bodies – basic, applied and clinical – and of current practice, this article attempts to provide continuity to the design research process in architectural lighting, while eliciting different points of view. Based on this analysis, the knowledge obtained from basic research will potentially help architectural lighting teams to interpret the context of use of their designs when pursuing applied research. They will be able to predict the outcomes of their various architectural lighting concepts and build lighting scenarios around them, which can strategically drive the design towards an innovative outcome. Applied research, on the other hand, supports design innovation by focussing on the interpretation, translation and implementation of the design constraints. The knowledge generated from the concurrent research during the design process can be applied in the relevant design stage. And finally, the utilisation of knowledge generated from clinical research can lead to new designs and discoveries. It is also important to note that both applied and clinical research support the strategic role that research plays in creating new market niches and commercial opportunities. This is based on the premise that innovation occurs within the activity and is generated by people (12). The analysis is listed in Table 1.

5. Conclusion
The three modes of research used in the pursuit of knowledge are either specific to a design project, relevant to a class of design problems, or fundamental to the very nature of design. Basic research in design should be highly valued, savoured, and encouraged (2). For the architectural lighting community to become a scholarly field with the objective of contributing intellectual merit and long-lasting knowledge, it cannot exist without basic research. Two of these modes, namely applied research and clinical research, are identified as strategic for creating new market niches as innovation occurs within the activity and is created by people. Therefore the architectural lighting community must have strong ties to applied and clinical research, and ultimately impact practice through the transfer of processes, methods, tools, and technology. This in turn can lead to innovations to meet societal needs and the development of the next generation of design leaders for an innovation economy. The framework presented here will evolve along with architectural lighting as a discipline, with potential for supporting new design services to become more innovative and human-centred as people and their activities contribute towards it.