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**Swedish Theory of User Centred
Lighting Design**

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Swedish Theory of User Centred Lighting Design

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Abstract

This paper concerns the development of lighting science theoretically and practically in Sweden. The development started with the work of professor emeritus Anders Liljefors at KTH 30 years ago. 15 years later Håkan Franson, Anders Liljefors and Monica Säter together developed the topic further at the Department of lighting science at Jonkoping University. The work is still ongoing, but now outside Jonkoping University, and is concerned updated theory, methods and processes and didactics in lighting design. The user centred approach to lighting design is based on the interaction of man, light, colour and space and handle reality according to the need of the user and the changes in daylight seen during the year. By that a natural approach to lighting is developed and the complementary lighting mimics daylight at the place where the user lives. The user is seen as an individual with a need of a broad span of levels of light in the task lighting. The design of the lighting application is done related to the indoor contrast situation. The ambient light is divided from the task lighting to ensure an individual experience of visual comfort. Buildings today use a lot of energy. A scientific goal is to develop technical solutions that decrease the use of energy in buildings close to zero. By that, light related theory, methods, processes, and goals need to be defined and used in the most possible energy efficient way. In the same time need the lighting application meet goals according to the user's needs psychologically, physiologically and visually, in a well functioning way. Here the development in Sweden is useful and has the possibility to show in what way this can be done.

Keywords: User centred lighting design, Lighting Science; lighting applications

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Introduction

Anders Liljefors Professor Emeritus in Lighting Science at Royal Institute of Technology and Jonkoping University

AL: I came across the need of education in lighting science as an architect. I had the same starting point as everyone else. After some time I began to reevaluate my knowledge in Lighting technology, when I realized that it did not work out in reality. I developed pedagogic methods for how to train students in evaluating light in spaces and luminaries. Successive scrutiny of theoretical starting points for the development of light sources and design of luminaries and lighting design, became an important part of my work.

Håkan Franson Interior Designer, Industrial Designer, Initiator of the Education and the Former Head of the Department of Lighting Science at Jonkoping University

HF: Lighting Science is of a great complexity and a multidisciplinary topic. Lighting applications should from this perspective be designed with good technical solutions and in a way that is supportive for the user. To be well functioning, luminaries and lighting applications need to be designed from the perspective of the user.

My opinion, in the beginning of 1990 was that the human and space related aspects of lighting design was neglected and not well represented in the design process. The topic was handled mainly as a discipline of technique. The design was recommended by authorities and institutions, set of regulations, standards and only with a limited connection to user centred lighting design. My insight's according to the situation motivated me to initiate and later establish an education based on a holistic and user centered education philosophy with an ambition to adjust the predominant situation within lighting design. With a background of being an architect and industrial designer with 25 years of experience within the lighting industry and interior and application business, was for me the way light was handled, from a user aspect, insufficient.

The product development and the lighting design process for public spaces are mainly ruled by techno-economical conditions and rules/regulations from authorities and institutions. The work with daylight and artificial light as well, is of a multidisciplinary character and has as a primary task, to give the user a satisfying illuminated environment in a comfortable way. With the background here mentioned was important parts of the topic not handled from a space and user perspective. Therefore there was a need of developing theory about user centred lighting design.

Monica Säter: Dr of Technology, Researcher in Lighting Science, Teacher in Lighting Design, the Former Program Leader and Head of the Department of Lighting Science at Jonkoping University

MS: I was from the beginning an artist and a painter that was interested in lighting design. When I was invited to work with the education in Lighting

Design in Jonkoping (1999) the contact with Anders Liljefors and Håkan Franson increased my knowledge in how to work with lighting analysis's. I learned how to evaluate spaces, daylight, indoor lighting the user's need of light, knowledge about luminaries, how to support the user and theory about lighting design. When I had to build the lighting design program further in 2001, after Håkan Franson resigned, I needed to develop didactics and theory in lighting science. It was Anders Liljefors' and Håkan Franson's deep knowledge in how to evaluate luminaries, spaces and theory about lighting science, handed over to me during many years, that made it possible for me to manage to develop the education further after both resigned and left the Department. I was also accepted as a Phd student 2004. The buildup of the education and new theory about lighting design, was developed at the same time [Säter 2013:1, 2013:2, 2013:3, 2013:4].

Method

The paper is based on a (still ongoing) 15 year long discussion about how to build the topic lighting science and was written down for the Atiner conference. The discussion became the origin for a pedagogic concept for lighting design and a two year program in Lighting Science at Jonkoping University, a Thesis and a post doc project. The discussion was used as a tool to build the program that then educated a great part of the Swedish lighting designers, all trained in the user centred lighting design process.

Results

Anders Liljefors, Professor Emeritus in Lighting Science at Royal Institute of Technology and Jonkoping University

AL: I started to work as a teacher in Lighting Science 1970. My starting point was to create well-functioning spaces for the user. The pedagogic methods that I developed were based on training of the student ability to see and evaluate. In my work I broadened the education to concern visual observations of daylight and the complementary lighting. These pedagogic methods focus upon the relationship visual–physical, regarding 7 specific elementary qualities of visual perception related to prevalent physical stimuli [4]. Experimental full-scale studies will successively develop reliable knowledge of the rule-bound relationship "visual/ physical", in short "vis–phys" – which presents a most reliable tool by architectural lighting design [4].

In my work as a teacher I found that the basic theory of Lighting technology and international agreements hampered the development of the design of the practical applications [5, 6]. My buildup of theory more and more came to focus on recommendations and international agreements that hinder a positive development and need to be updated. As a part of my teaching I

started to do a revision of basic theory in lighting technique that is needed to improve the topic theoretically.

The education that I built in Sweden, and theory promoted by the education, is based on the fact that there is no visible radiation and that there is no direct connections between stimuli and visual perception. This was found out by Einstein already at 1905 [1]. The Nobel prize 1921 was given for the research that points out that the electromagnetic radiation 10–15-104 nm is composed of not visible photon flows. The Nobel prize was 1967 given to Granit, Hartline, and Wald 1930-50 [2] because of their research about the lack of direct connections with photons, stimuli and perceived qualities of visual perception. These scientific findings have not been accepted yet by CIE and CIPM. The basic theory originated from CIE and CIPM contributes to the development of recommendations for lighting design and have an impact on education, lighting engineering and control and the production of electric lamps and fitting.

Education of lighting engineering and design should be founded upon today's science of human vision and endocrinology, physiologically and physically. Education and practice according to CIE Lighting Technology still today basically regard workspace lighting by recommendations of Lux-values according to specific task/ it's close surroundings/ space (5:3:1). The common result hereof is evenly lit spaces, which offer monotonous, dreary environments. Visual conform spaces conflict to most user's and the architect's aim of pleasant, stimulating surroundings. The visual perceived qualities of the user's visual work and environment should be attended to. Though, appropriate spectral and spatial distribution of light, stating elementary qualities of visual environment are rarely fulfilled.

At the Department of Lighting Science, Jonkoping University, 1999-2011, the education program all from start related to the principles accounted for by the compendium Lighting Visual-Physical [4]. The student's background showed wide differences. During the Light-Lab sessions, the discussions among the students on prevalent light settings, in general gave interesting output to the reason of different background. The apparent lack of coherence of instrumental lighting measures and corresponding visual experiences awaked questions of reliability.

This inadequate state of the matters must not be hidden, but openly admitted to open for revised, scientific present lighting theories. These will support lighting engineering and design to realize optimal lighting quality within current energy limits – in support of the users worldwide.

Photometry today – correlated according to the "human sensitivity to light" – by education of lighting Technology taught to measure light as visual perceived. This elementary statement is contradicted since long [1, 2].

Håkan Franson, Interior Designer, Industrial Designer, Initiator of the Education and the Former Head of the Department of Lighting Science at Jonkoping University

HF: In the end of the 1980 a discussion took place in a small group of people in the lighting business about how the lighting design should be developed. The situation was analyzed and it was described why and how an education in lighting design should be developed. The discussion declared the need of new knowledge and comfort for the user. A concept of ideas was developed by undersigned resulting in theoretical courses moderated by qualified teachers and practically performed through lighting design projects, directed towards concerned professional groups in the lighting design process as architects, electrical consultants, assembling fitters, real estate managers among others.

The concept idea about the education was presented for the Bertil and Britt Svenssons Foundation for lighting technique, and was accepted with a generous economical support for an educational activity.

To get experience and routines to work out during 1994-1996 was at 20 occasions courses held. It was single lectures, one day course and two weeks courses. The courses had as a theme daylight, and artificial light connected to the user, including the space and the lighting design process. The test activity got a positive response from the students and from the professional participants from the design business and institutions of municipalities. Positive evaluations of the activities and discussions with business representatives encouraged a higher level of ambitions towards an increased ambition to establish a new professional group with a broaden knowledge in lighting design.

Undersigned got further financial support from Bertil and Britt Svenssons foundation and was asked to formulate a concept for an education with a focus on the lighting design process based on the previous performed short courses. A work group was founded for the development of course plans and educational philosophy. Professor Anders Liljefors at KTH- Department of architecture got the function as an academic leader of the topic, together with experienced representatives for the product and lighting design business and with me, Håkan Franson, as responsible for the coordination of the education.

The content and the goal of the education were discussed thoroughly. The group discussed the different parts of the lighting design process and the pedagogic resources available for education in the lighting design process to realize the educational goal, user centred lighting design.

The concept of the education had a content of user aspects on lighting design and technique to teach the students how to fulfill the ambition about user centred lighting design process. The education concept was presented for the contractor and accepted in 1996. The education was placed at the Jonkoping University and I was assigned as the Head of the Department. By that was this necessary education established. Bertil and Britt Svensson Foundation for Lighting Technique supported financially the buildup of the education and gave recourses for other activities in order to get an increased number of students for the education.

Educational facilities were given and were equipped as a laboratory with areas for lecturing and for individual studies and to be able to perform study project in full size. The students was able to realize study projects in full size and by that get an increased understanding by the projects of the theoretical studies and project related lectures.

To develop the established educational philosophy was Monica Säter engaged as course leader. She added with her background a stringent and very ambitious academic pedagogic approach to the topic and to the development of the course plans.

After the development, financing and establishing of the institution I resigned 2001 and the responsibility was handed over to Monica Säter for further academic development, in didactics as well as theoretically.

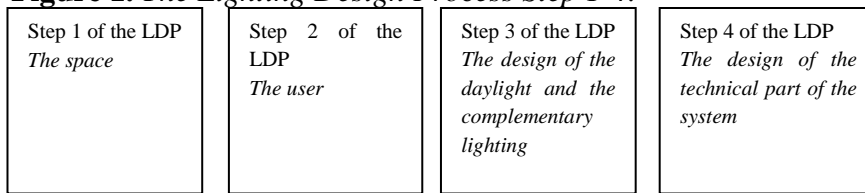
This is a summarized description of the start up of the Department of Lighting Science until year 2001. The education was then developed further in a positive way. The education is today 2 year long with a voluntary extra third year. The educational philosophy and pedagogic concept have been kept and developed further. Approx 300 students have got a University degree in lighting design. They have been successful in their work due to their increased knowledge in lighting and their user- centred approach.

Monica Säter: Dr of Technology, Researcher in Lighting Science, Teacher in Lighting Design, the Former Program Leader and Head of the Department of Lighting Science at Jonkoping University

MS: The education that Anders Liljefors developed in lighting science in Stockholm at KTH emerged from a space and user perspective. He developed a training program for the students in lighting analysis, evaluation of luminaries, analysis's of the space and the users need for light. Håkan Franson in the same way, originated in his work with the education in lighting science in Jonkoping, from the space, luminaries and the user. My own background as a painter and an artist, working with public spaces, was focused on the creation of a decorative and pleasant space for the user.

From these three different but still quite similar backgrounds in architecture, interior design and art for public spaces and with this three person's special interest in the support of the user, was the approach to the buildup of the education given. But from the first day was every part of the lighting design process seen as of equal importance. The education built in Jonkoping taught the basic lighting design process that starts with the space, goes on with the users need of light, the design of daylight and a complementary lighting and as the fourth step the technique needed for the lighting system. It was seen of equal importance that all four steps should be professionally performed. In a co-work between Franson, Liljefors and Säter was the education developed. By that the Swedish lighting Industry got lighting designers with a University Diploma of 120 ECTS to be used as personnel. They were all trained in a professional way within all four steps of the lighting design process.

Figure 1. *The Lighting Design Process Step 1-4.*



Today since 3 years, the work with the development of how to educate in user centered lighting design is still ongoing, but now outside Jonkoping University. Today it concerns the buildup of a Lighting Academy in Sweden. The focus for this new platform is to serve society and the lighting industry concerned updated theory in lighting science, development of methods and processes and didactics in lighting design. Many issues are important to handle. As examples can be mentioned how to use the new technique on the market for light sources in a successful way and the urgent need of well educated teachers, both today and tomorrow, both important issues for the lighting industry.

As a result of the theoretical development within the education, was the interaction of man, light, colour and space described based on reality and not in a fictive way, according to the need of the user and the changes in daylight.

This approach is beneficial for the user and opposes the common approach of recommendations from ISO, stating 500 Lux on the working table for everybody – all the time and static levels of ambient light.

Instead a more natural approach is developed that mimics daylight at the place where the user lives. This can shortly be described as daylight is used as ambient light. The complementary artificial ambient light is connected to the levels of light outdoors and the way daylight appears in the space. This gives a good support for human diurnal rhythm and is energy efficient. Ambient light is divided from the task lighting to ensure an experience of visual comfort. The user is seen as an individual with a need of a broad span of levels of light in the task lighting. The design of the lighting application is done in connection to the indoor contrast situation in the space. This is described further in the references for this paper.

Conclusion

Anders Liljefors

AL: When the lighting design is based on the user, this puts high demands on the way lighting design is performed. New theories of lighting, founded upon topical science will open for clear understanding of "man and lighting" and should be used in education of the lighting designers.

Now valid $V(\lambda)$ -curve is inadequate (as leaning upon monochromatic stimuli) and should be replaced by a new definition of Photometry, laid upon topical vision science regarding the spectral absorption of human cone cells S,M,L (a study hereof shown by figure 1, ref. 5). Lighting claims according to international CEN standard lean upon stated photometric units of lighting,

according to recommended values of lm, Lux, cd, etc. related to specific visual tasks. These, though, misled by the $V(\lambda)$ -curve.

Natural daylight in general forms elementary design references by architectural design of space, exterior and interior. Electric lighting on the other hand, in general will follow CEN-standards of Work Environment Lighting, which are based upon international established rules – i.e. terms and theories according to CIE Lighting Technology and measurement system CIPM Photometry. These generally respected International Commissions, though, all since 1913 were misled by the term visible radiation, still valid according to eILV 2012, [3, p 5.] This in spite of the fact that this term was scientifically dismissed 1905 [1]. CEN-standards of lighting needs according Workers health, relate to recommendations of lighting needs by photometric measures according to specified visual tasks and surrounding space. When judged by the users, the perceived result of lighting according to these standards shows low appreciation [7]. One apparent reason hereto is the fact that international established standards of CIE, CIPM and CEN – conflicting with topical science – ignore the elementary claim of topicality according to EEC Directive 89/39.

Håkan Franson

HF: In the work with the necessary change of the way light is handled in the building process demand the following actions:

- Widen and deepen the knowledge into the lighting design process used to day, in a way that gives a good support and health to the user.
- Use scientific results for information and education to get qualified lighting designers.
- Increase the knowledge about light among authorities and institutions.
- Develop the control of products and lighting applications related to actual daylight conditions.
- Increase the development of qualified education in lighting design.
- Strengthen the architects knowledge and responsibility for lighting design in the build environment in a close cooperation with the new professional group, lighting designers

If this can be developed we are on our way towards acceptable lighting applications with a big potential for energy efficiency, for support of the user according to their needs visually and for health.

Monica Säter

MS: When the user is the focus for the process of lighting design, the buildup of a theory about user centred lighting design is logical. When education in lighting design and the development of theory in lighting science

is based on an extensive care about the user this will ensure society a low level of light-related direct and indirect negative effects of the use of a complementary lighting. Here the development in Sweden might be useful and inspire other countries to build education and theory in a similar positive way.

Figure 2. Liljefors **Figure 3. Franson** **Figure 4. Säter**



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