

Graduation Plan

Master of Science Architecture, Urbanism & Building Sciences



Graduation Plan: All tracks

Submit your Graduation Plan to the Board of Examiners (Examencommissie-BK@tudelft.nl), Mentors and Delegate of the Board of Examiners one week before P2 at the latest.

The graduation plan consists of at least the following data/segments:

Personal information	
Name	Bart Johannes Mooren
Student number	5644747

Studio		
Name / Theme	AR3AH115, Revitalising Heritage studio (KB the Hague)	
Main mentor	Dr.-Ing. (Uta) Pottgiesser	Design Tutor
Second mentor	Dr. M. (Emeline) Lin	Research Tutor
Argumentation of choice of the studio	<p>Given that my previous design studios in the master's program have all focused exclusively on new-build projects, I considered it both evident and valuable to explore an adaptive reuse project for a change. Additionally, I have long been intrigued by library architecture, as it offers a rich opportunity to integrate one's architectural expression and personal interests into a meaningful public program. For these reasons, I am pleased with my studio choice and believe I am currently engaged in a highly relevant and intellectually stimulating research project.</p>	

Graduation project	
Title of the graduation project	<p>Sustainable Libraries. LIGHTING, THE PATH TO KNOWLEDGE: Enhancing cognitive performance and knowledge acquisition in future libraries through the lighting landscape</p>
Goal	
Location:	Royal Library in the Hague, the Netherlands (PR WILLEM-ALEXANDERHOF 5, 2595 BE Den Haag)
The posed problem,	Libraries have evolved from being exclusive book repositories to becoming interactive and dynamic learning spaces, with a focus on accessibility, engagement and adaptability.

However, the challenge of creating an environment that optimises cognitive performance and knowledge acquisition remains underexplored in contemporary library design. A key factor in creating such an environment is lighting. The role of lighting extends beyond mere illumination; it is a crucial factor in cognitive performance, user-driven knowledge acquisition, and overall well-being (Çelik et al., 2024).

The static and monotonous nature of current library environments often fails to support the diverse cognitive needs of users. As Matthijs van der Meulen (intermediary at the Royal Library of the Netherlands) notes: 'Every day is the same here' and 'One doesn't notice the seasons here,' highlighting the lack of adaptive and dynamic lighting approaches in existing library environments.

Despite extensive research on the impact of lighting on cognition in the workplace and educational contexts, and several guidelines for energy-efficient and functional lighting in buildings being written, its application within libraries—particularly heritage buildings such as the Royal Library in The Hague—remains underexplored. In this context, the Royal Library serves as an ideal case study for exploring how lighting strategies can be integrated into an existing heritage building, with the aim of optimising both the cognitive and spatial needs of users while respecting its historical significance.

<p>research questions and</p>	<p>MAIN QUESTION How can the lighting landscape be designed to stimulate user-driven knowledge acquisition and cognitive performance in the 'Future Library'?</p> <p>SUB-QUESTIONS -What is the role of the lighting landscape in influencing the neurological processes that drive knowledge acquisition and cognitive performance in a library environment? -What spatial lighting strategies enhance user-driven knowledge acquisition and cognitive performance within libraries? -What are effective lighting strategies to integrate into the existing structure of the Royal Library to optimise knowledge acquisition and cognitive performance?</p>
<p>design assignment in which these result.</p>	<p>A clear research gap exists in linking the neurological effects of the overall lighting landscape to its spatial role in library design and its impact on user-driven knowledge acquisition and cognitive performance. This research aims to address this gap by exploring how lighting strategies can be optimised to enhance cognitive performance and support user-driven knowledge acquisition in future libraries. Drawing on insights from neuroscience, architecture, and case studies, the goal of this study is to develop an evidence-based spatial lighting framework that positions (day)light as a neurological stimulant. The outcome will contribute to the discourse on neuroarchitecture and guide future library design in aligning spatial lighting with cognitive needs. This evidence-based lighting framework will serve as the foundation for the architectural reimagining of the Royal Library (KB) in The Hague, ensuring a clear and traceable translation from scientific research into spatial design decisions that enhance cognitive performance.</p>

Process

Method description

In order to ensure a comprehensive exploration of the research questions, this study integrates four complementary methodological strategies (mixed-method approach): literature review, interviews with KB's users, survey with KB's users, and design-oriented research. The combination of these methods offers both theoretical insight and practical contributions, ensuring a comprehensive approach to the research questions. The next chapter explains how each method will be applied and its role in the overall research.

Literature and general practical references

To establish a solid theoretical foundation, the study's literature review is structured around key themes that align with the main and sub-research questions. The selection of relevant academic and scientific sources is guided by carefully chosen keywords reflecting the core themes of this study. The primary keyword and main search term is "Library lighting design," which helps identify research related to lighting strategies in libraries.

However, as this term alone does not cover all relevant aspects, additional search terms will be used, including "Lighting and cognitive performance," "Lighting design for study spaces," "Daylight strategies for academic environments," "Library lighting design and user engagement," "Lighting design in academic and heritage buildings," "Lighting impact on learning performances," and "Lighting effect on books."

The literature review is organised around two interconnected domains to provide a comprehensive understanding of the topic. First, literature on the impact of (day)light on neurological processes that drive knowledge acquisition and cognitive performance will be examined in order to integrate insights from neuroscience and environmental psychology regarding the effects of (day)light on knowledge acquisition and cognitive performance. Second, research on (day)light architectural design and concepts will be explored, focusing on how lighting strategies in educational and cultural environments, including libraries, can enhance knowledge acquisition and cognitive performance. These are often explained through the investigation of useful case studies, investigating real-world applications.

To maintain focus and feasibility, the literature study has been based on a carefully selected pool of approximately 20 to 30 sources. These sources were selected based on their direct relevance to the research questions, as determined by an evaluation of abstracts, methodologies, and conclusions. The integration of insights from diverse disciplines is intended to provide a comprehensive understanding of the relationship between daylighting, knowledge acquisition, cognitive performance, and their architectural context. Figure 1 presents a matrix of the selected sources that inform this literature review, highlighting the associated themes and keywords identified within each source.

AUTHOR AND YEAR REFERENCES	Impact of (day)light on neurological processes that drive knowledge acquisition and cognitive performance					(day)light architectural design and concepts						
	Knowledge/learning	Stimulant/stimuli	Cognitive functions/performance	Neurological/neural	Circadian rhythms	Library	Spatial element	(Day)light integration	Lighting strategies	Control/lighting systems	Optimal lighting/daylight optimization	(lighting) Design
Ale, T., & Yunus, O. (2022)												
Baeza Moyano et al. (2020)												
Baker, N., & Steemers, K. (2002) [Book]												
Beñia et al. (2024)												
Celik et al. (2024)												
Conservation Center for Art & HA (2024)												
Cungiono et al. (2021)												
Fanpu et al. (2024)												
Hawkins, H. (2024)												
Heschong, L. (2021) [Book]												
Izmir Tunahan et al. (2021)												
Jamrozik et al. (2019)												
Jung et al. (2024)												
Klic, D. K., & Hasirci, D. (2011)												
Kong et al. (2022)												
Lehmann, S. (2023)												
Lushington et al. (2016) [Book]												
Melman, D. (2009)												
Mostafawi et al. (2024)												
Perera, N., & Nirma Swaris. (2017)												
Sanaz Ahmadpoor Samani. (2012)												
Sinem Saralioglu. (2025)												
Singh et al. (2020)												
Wajaya et al. (2019)												
Yang, W., & Jeon, J. Y. (2020)												

No role – The mentioned theme and related keywords are not addressed in the article/book.
 Minor role – The theme and related keywords are briefly mentioned or play a secondary role.
 Major role – The theme and related keywords are central to the article/book and play a significant role in its argument or findings.

Figure 1. Literature matrix illustrating themes and keywords. Created by author.

Ale, T., & Yunus, O. (2022). Dynamics of Windows for Effective Daylighting Design Strategies in Academic Library. *Tropical Journal of the Built Environment (TJOBE)*, 3(2). Retrieved from: <https://jabu.edu.ng/wp-content/uploads/2023/09/3-Dynamics-of-Windows-for-Effective-Daylighting-Design-Strategies-in-Academic-Library.pdf>

Baeza Moyano, D., San Juan Fernández, M., & González Lezcano, R. A. (2020). Towards a Sustainable Indoor Lighting Design: Effects of Artificial Light on the Emotional State of Adolescents in the Classroom. *Sustainability*, 12(10), 4263. Retrieved from: <https://www.mdpi.com/2071-1050/12/10/4263>

Baker, N., & Steemers, K. (2002). *Daylight Design of Buildings: A Handbook for Architects and Engineers*. Retrieved from: <https://www-taylorfrancis-com.tudelft.idm.oclc.org/books/mono/10.4324/9781315073750/daylight-design-buildings-nick-baker-koen-steemers>

Bellia, L., Diglio, F., & Fragliasso, F. (2024). Office workers' performance and satisfaction with the luminous environment under standard and daylight mimicking LEDs. *Journal of Building Engineering*, 97, 110942. Retrieved from: <https://www.sciencedirect.com/science/article/pii/S2352710224025105>

Çelik, M., Didikoğlu, A., & Kazanasmaz, T. (2024). Optimizing lighting design in educational settings for enhanced cognitive performance: A literature review. *Energy and Buildings*, 328, 115180. Retrieved from: <https://www.sciencedirect.com/science/article/pii/S0378778824012969>

Conservation Center for Art & Historic Artifacts (2024). *Light Exposure for Artifacts on Exhibition*. Retrieved from: https://cacha.org/sites/default/files/attachments/2020-06/2020_Light%20Exposure%20for%20Artifacts%20on%20Exhibition_HH.pdf

Cungiono, K., Indrawan, H., & Mariana, M. (2021, August 8). *Artificial Lighting Design in The Japan Foundation Library (Case Study: The Japan Foundation Library Design, Jakarta)*. *Www.atlantis-Press.com*; Atlantis Press. Retrieved from: <https://www.atlantis-press.com/proceedings/icebsh-21/125959546>

Fanpu, M., Shou yi, W., & Hua, F. (2024). Research on the health lighting scheme of university library reading room. *Heliyon*, 10(19), e38089. Retrieved from: <https://www.sciencedirect.com/science/article/pii/S2405844024141205>

Hawkins, H. (2024). To what extent does lighting affect students' preference for seating in the Georgia Southern University Henderson Library? Honors College Theses. Retrieved from: <https://digitalcommons.georgiasouthern.edu/honors-theses/934/>

Heschong, L. (2021). *Visual delight in architecture: Daylight, vision and view* (G. von Ahnen, Ill.). Routledge, Taylor & Francis Group.

Izmir Tunahan, G., Altamirano, H., & J. Unwin Teji. (2021). THE ROLE OF DAYLIGHT IN LIBRARY USERS' SEAT PREFERENCES. Retrieved from: https://www.researchgate.net/publication/355862078_The_role_of_daylight_on_users'_seat_preferences

Jamrozik, A., Clements, N., Hasan, S. S., Zhao, J., Zhang, R., Campanella, C., Loftness, V., Porter, P., Ly, S., Wang, S., & Bauer, B. (2019). Access to daylight and view in an office improves cognitive performance and satisfaction and reduces eyestrain: A controlled crossover study. *Building and Environment*, 165(106379), 106379. Retrieved from: <https://www.sciencedirect.com/science/article/pii/S036013231930589X>

Jung, D., An, J., & Hong, T. (2024). Exploring the Relationship Between Office Lighting, Cognitive Performance, and Psychophysiological Responses: A Multidimensional Approach. *Building and Environment*, 111863–111863. Retrieved from: https://www.sciencedirect.com/science/article/pii/S0360132324007054?casa_token=s5eJ7N4UXngAAAAA:LCKiibYqRrsVQ0AIN91Trqac3x_J_ea0WfBBFbktBrZ9U09XPluGzJvHu8ujPa0ImzahYZ1

Kilic, D. K., & Hasirci, D. (2011). Daylighting Concepts for University Libraries and Their Influences on Users' Satisfaction. *The Journal of Academic Librarianship*, 37(6), 471–479. Retrieved from: <https://www.sciencedirect.com/science/article/pii/S0099133311001571>

Kong, Z., Liu, Q., Li, X., Hou, K., & Xing, Q. (2022). Indoor lighting effects on subjective impressions and mood states: A critical review. *Building and Environment*, 224, 109591. Retrieved from: <https://www.sciencedirect.com/science/article/pii/S0360132322008216>

Lehmann, S. (2023). Reimagining the Library of the Future. From Social Condenser and Community Hub to Regenerative Design. *Public Library Quarterly*, 1–37. Retrieved from: <https://doi.org/10.1080/01616846.2023.2242626>

Lushington, N., Rudorf, W., & Wong, L. (2016). *Libraries: A design manual*. Birkhäuser.

Malman, D. (2009, October 10). *Lighting For Libraries*. SlideShare; Slideshare. Retrieved from: <https://www.slideshare.net/slideshow/lighting-for-libraries/2184810>

Mostafavi, A., Vujovic, M., Xu, T. B., & Hensel, M. (2024). Impacts of Illuminance and Correlated Color Temperature on Cognitive Performance: A VR-Lighting Study. *ArXiv.org*. Retrieved from: <https://arxiv.org/abs/2406.02728>

Perera, N., & Nirma Swaris. (2017, December). Good Reading Light: Visual Comfort Perception and Daylight Integration in Library Spaces. ResearchGate; unknown. Retrieved from: https://www.researchgate.net/publication/321719388_Good_Reading_Light_Visual_Comfort_Perception_and_Daylight_Integration_in_Library_Spaces

Sanaz Ahmadpoor Samani. (2012). The Impact of Indoor Lighting on Students' Learning Performance in Learning Environments: A knowledge... ResearchGate, 3(24). Retrieved from: https://www.researchgate.net/publication/281146405_The_Impact_of_Indoor_Lighting_on_Students

Sinem Sarialioglu. (2025). ENHANCING COGNITIVE PROCESSES. 55(2), 42–45. Retrieved from: <https://journals.sagepub.com/doi/epub/10.1177/03606325251318553>

Singh, P., Arora, R., & Goyal, R. (2020). Impact of Lighting on Performance of Students in Delhi Schools. Lecture Notes in Civil Engineering, 95–108. Retrieved from: https://www.researchgate.net/publication/338355699_Impact_of_Lighting_on_Performance_of_Students_in_Delhi_Schools

Wijaya, D. D. A., Utami, S. S., Adi, G. S., & Prayitno, B. (2019). Optimization of Natural and Artificial Lighting System Design in the Library of the Faculty of Economics and Business, Universitas Gadjah Mada. 2019 IEEE 6th International Conference on Engineering Technologies and Applied Sciences (ICETAS). Retrieved from: https://www.researchgate.net/publication/342225784_Optimization_of_Natural_and_Artificial_Lighting_System_Design_in_the_Library_of_the_Faculty_of_Economics_and_Business_Universitas_Gadjah_Mada

Yang, W., & Jeon, J. Y. (2020). Effects of Correlated Colour Temperature of LED Light on Visual Sensation, Perception, and Cognitive Performance in a Classroom Lighting Environment. Sustainability, 12(10), 4051. Retrieved from: <https://doi.org/10.3390/su12104051>

Reflection

1. *What is the relation between your graduation (project) topic, the studio topic (if applicable), your master track (A,U,BT,LA,MBE), and your master programme (MSc AUBS)?*

The subject of the present graduation project is concerned with the intersection of architecture, neuroscience, and lighting design. The decision to enrol in this studio was motivated by the emphasis on the adaptive reuse of public architecture, a subject that holds particular importance, particularly in light of previous experience working exclusively on new-build projects in earlier master's studios. This graduation studio offers an opportunity to reimagine the Royal Library. This is achieved not by treating lighting as a purely technical requirement, but by using it as a primary spatial driver. The project combines this design context with a scientific exploration of how architectural lighting can function as both a spatial and neurological tool to support cognitive performance and knowledge acquisition. In doing so, it is in line with the studio's emphasis on the development of library design that is both future-proof and sustainable.

2. *What is the relevance of your graduation work in the larger social, professional and scientific framework?*

The relevance of this study lies in addressing a critical gap in contemporary library design by establishing a link between lighting and neurological stimulation, as well as spatial experience. As libraries continue to evolve from static repositories into dynamic learning environments, the findings will offer guidance for designing cognitively supportive and user-oriented lighting strategies, particularly in heritage contexts such as the Royal Library in The Hague. This case study will demonstrate how adaptive lighting design can be integrated into an existing architectural framework.