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	Pranay Prakash Khanchandani
Student number	5494389

Studio		
Name / Theme	Building Technology	
Main mentor	Dr. Alessandra Luna Navarro	Assistant Professor in Façade Design and Engineering group at the Faculty of Architecture and Built Environment, TU Delft
Second mentor	Dr. Eleonora Brembilla	Assistant Professor in Building Physics and Services group at the Faculty of Architecture and Built Environment, TU Delft
Argumentation of choice of the studio	My interest through the course at TU Delft is around Façade Design and technologies. Through this masters thesis I aim to integrate occupant comfort and climate design into my scope of interest.	

Graduation project	
Title of the graduation project	User Archetypes for Façade Technologies
Goal	
Location:	Delft
The posed problem,	A concerning fact about current design methodologies is that they are energy and optimization based, and do not necessarily address different occupant requirements in early stages of design. Designing energy-efficient structures with simply economic considerations in mind does not always result in occupants having a comfortable indoor environment. In reality, if energy conservation measures are optimized for these goals, they may be able to improve occupant comfort in addition to cost savings (Andargie, Touchie, and O'Brien 2019). Since shading systems influence not only comfort but also the spatial feel of the room, they need to be personalized for occupants. The additional relation of the effects occupant comfort on their productivity, creates a necessity to address occupant preferences in building envelope design to achieve the energy efficiency the building is designed for. But, taking the preferences of single users will not be effective in this scenario. Offices in contemporary commercial buildings are quickly evolving into multi-user settings that encourage a collaborative working style. Open offices, low partitioned spaces, or flex work spaces are created from closed offices where users do not have designated workstations (Despenic et al. 2017). The archetype method, that addresses the types of users through profiling of a data-set of existing users, encompasses a series of strong tools and socio-cultural perspectives through the use of character profiles, scenarios, and storyboarding to teach designers how to engage more in the background, perception, and behaviour of different user groups when

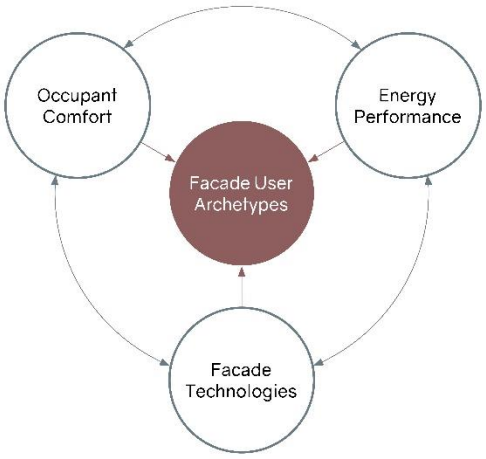
	developing their design solutions (Tvedebrink and Jelic 2018). There are many guidelines that address user perception and behaviour with respect to indoor comfort but they often generalizes comfort standards (Heydarian et al. 2017) (Bennetts et al. 2020). Hence, Personas or Archetypes need to be developed to better understand user comfort and preferences to provide a certain level of personalisation to building shading system desi
research questions and,	The primary question of the research is, 'How can shading solutions be personalized to provide occupant comfort and improve energy performance of buildings? The following sub questions need to be answered in order the answer the primary research question. Each sub-question relates to chapters within the thesis. 1. What personal user factors should be considered when evaluating user preferences for building shading systems? Which external factors influence occupant perception of indoor comfort? 2. How can we classify building shading systems? What are the important shade parameters that need to be evaluated based on their effect on Indoor environmental quality and energy performance? 3. What are the common metrics and simulation tools used to understand the impact of shading technologies on occupant comfort and energy performance? 4. What are common clustering methods that can be used to design Facade user Archetypes ? How can effective Archetypes be designed using the same to address the various types of user demands with respect to building shading systems? 5. How can shading systems be objectively rated to compare their multi-domain performance and how can user preferences be integrated into this rating? 6. What is the potential of using the developed Archetypes within design scenarios for new users
design assignment in which these result.	The primary objective of the research is to develop user archetypes for facade design. The use of these Archetypes that will help to categorize occupants into clusters with similar background, perceptions, preferences and behaviors. Following the Research Question mentioned previously, the research aims to develop a relation between the personalization of facade shading technologies on occupant comfort and the resulting energy performance of the building by means of simulation tools. Once established, the Archetypes can be used to understand the responses of a larger set of users. The core objective is to research the implications of placing people's preferences and behaviors at the center, enabling for the development of creative solutions on the performance of buildings through simulations and/or assessments. Finally, the resultant Archetypes will be verified by methods described in the methodology. The design assignment in the research is to develop personalized shading technology solutions for user Archetypes.

Process

Method description

The research consists of 4 parts. The first part involves conducting of a systematic literature review to understand the simulation tools that can be used to compare shading systems objectively and to understand the user characteristics and external factors that play a role in influencing the preferences of individual users. The second part is a controlled simulation of shading systems for performance

evaluation. The third part involves design of an occupant preference framework along with design and implementation of a facade user archetype survey. The final part processes the survey results and uses the results to form archetypes to re-evaluate the performance of shading systems to include the archetype preference and weights.



Literature Review –

The literature review aims to address two major sub questions. The first part of the literature review reviews the shading systems available in the market currently. The available shading systems are classified on the basis of design characteristics. Next, key parameters of the selected shading systems are determined to evaluate the aspects within shading systems that could be personalised for users. In order to evaluate the performance of building shades parameters, a summary of the performance metrics and the simulation tools associated with the same are reviewed. This establishes the simulations and tools required to evaluate the multi-domain performance of building shades.

The next part of the literature review addresses the factors that affect occupant preferences. Based on the initial review of literature pertaining to the topic of interest, 3 major factors affecting occupant preferences are determined: Personal factors, contextual factors and environmental factors. With this, a systematic literature review is conducted through Scopus with key words relating to users, indoor environmental quality, comfort, building envelopes and archetypes. The systematic literature review establishes sub-factors that affect occupant preferences.

As a conclusion to the literature review, a building shade classification is achieved where the shades to be personalised for users is determined. For the second part of the literature review, a conceptual framework of occupant preference and behaviour structure is designed. Finally, the literature review provides a broad idea of the types of user clustering and profiling methods used in the built environment.

Simulation –

The simulation part of the research attempts to objectively rate shading systems on their multi-domain performance. The shading systems are evaluated in 4 major domains: Energy performance, thermal performance, daylighting performance and finally view quality. Further, important metrics and the relating key performance indicators are determined within the individual domains. Within the individual shades, variable parameters (dependent on time of year and day), test parameters(shade parameters to be evaluated for performance) and fixed parameters(shade placement and type of operation) are

categorised. The test parameters such as size of shade element, color, openness factor amongst other solar and optical properties are determined to be systematically simulated. In order to execute this, the Energyplus and Radiance engines are used as they offer a possibility to accurately assess the performance of complex fenestration's. The systematic simulation for the selected shade types at multiple orientations iterates through the building shade test parameter variables. The results form the individual simulations are stored at 8 orientations and at a distance of 1m, 3m and 5m from the building envelope. In order to setup also a base scenario for comparison, a simulation for all environmental metrics is done using the same model while excluding the shading system. The results from the simulations are first evaluated on the basis of performance of the individual key performance indicators. Next, the key results for the individual shades are normalised and the shades are rated on the basis of the simulation results.

Survey design and data collection –

The conceptual framework developed at the end of the literature review helps create a hierarchy of factors that influence occupant preferences. A questionnaire is designed using Qualtrics with 4 major parts: Respondent personal factors, respondent environmental importance, respondent contextual factors and finally the respondent shading system importance, beliefs and visual preferences. The survey questions primarily with the use of a likert scale. This would assist to process preferences by relating the likert scale to a normalised quantitative scale. This method allows for numerical comparisons between different respondents for the same variable. The questionnaire makes use of images of roller blinds and venetian blinds with varying openness factors and slat sizes while asking respondents to rate the same on a 5 point likert scale. The same is done for different color of shading systems and also the impact to the interiors by various shading systems.

On receiving results to the survey, the results are processed, survey results that are below 80\% complete are excluded from further review. The remaining responses are taken forward for processing. The survey results are initially analysed to evaluate the responses and understand the distribution of responses received. A correlation and ANOVA test is conducted to explore any possible relations between the respondents personal and contextual factors their beliefs, preference and importance towards the indoor environment and shading systems. The outstanding features are noted as potential user features to be used when forming facade user archetypes.

Facade user Archetypes –

Based on initial statistical analysis of the survey responses user characteristics are used to develop various feature set combinations. The feature set combinations are then evaluated using Principle Component Analysis and the results analysed using Root mean square error and explained variance. This process determines the best explained feature set along with the ideal number of dimensions to be used for clustering. Unsupervised clustering methods are used to cluster the samples within a low dimensional feature space. The resulting clusters are evaluated through visual inspection and silhouette score. The ideal number of clusters with the highest silhouette score are taken forward as potential facade user Archetypes. The designed archetypes are analysed for mean value, median value and standard deviation within the designed archetypes.

Implementation of archetypes in design –

To evaluate the use of the designed archetypes in various design scenarios, a python algorithm is developed that assigns weights to the simulation results of the shading systems on the basis of the respondents individual responses and the archetype responses that the individual user is assigned to. The script loops through the individual user archetype to assign scores for visual preferences and weights to the environmental performance indicators of the individual shades. The scores of the

archetypes are compared with the scores of the individual users to determine if the archetypes can well infer the preferences of the users. The accuracy of the individual facade user archetypes is evaluated to see how well the individual archetypes perform.

Facade user archetypes for new users –

The archetypes developed in the research are situation based and not universal to design of all building envelope elements. In order to evaluate how well defined the archetypes are, new sample points are taken from the survey data set that is previously unseen by the clustering model. A semi-supervised learning model is used to infer which archetype best defined the new sample points. The allocation of the new users to the previously defined archetypes is tested by comparing of feature scores with the feature scores defined for the individual archetypes. This process defines whether designed archetypes can be used to infer the preferences and weights of new users or not.

Literature and general practical preference

The Research Al Horr, Yousef, Mohammed Arif, Amit Kaushik, Ahmed Mazroei, Martha Katafygiotou, and Esam Elsarrag. 2016. “Occupant productivity and office indoor environment quality: A review of the literature.” Building and environment 105:369–389.

Alghoul, Samah K, Hassan G Rijabo, and Mohamed E Mashena. 2017. “Energy consumption in buildings: A correlation for the influence of window to wall ratio and window orientation in Tripoli, Libya.” Journal of Building Engineering 11:82–86.

Alrubaih, MS, MFM Zain, MA Alghoul, NLN Ibrahim, MA Shameri, and Omkalthum Elayeb. 2013. “Research and development on aspects of daylighting fundamentals.” Renewable and Sustainable Energy Reviews 21:494–505.

Andargie, Maedot S, Marianne Touchie, and William O’Brien. 2019. “A review of factors affecting occupant comfort in multi-unit residential buildings.” Building and Environment 160:106182.

Anik, Sheik Murad Hassan, Xinghua Gao, and Na Meng. 2022. “Machine learning approach in the development of building occupant personas.” arXiv preprint arXiv:2207.11239.

Arens, Edward, Tyler Hoyt, Xin Zhou, Li Huang, Hui Zhang, and Stefano Schiavon. 2015. “Modeling the comfort effects of short-wave solar radiation indoors.” Building and Environment 88:3–9.

Ashrafian, Touraj, and Nazanin Moazzen. 2019. “The impact of glazing ratio and window configuration on occupants’ comfort and energy demand: The case study of a school building in Eskisehir, Turkey.” Sustainable Cities and Society 47:101483.

Atzeri, Anna Maria, Giovanni Pernigotto, Francesca Cappelletti, Andrea Gasparella, and Athanasios Tzempelikos. 2013. “Energy performance of shading devices for thermal and lighting comfort in offices.” In Building Simulation Applications BSA 2013: 1st IBPSA Italy Conference, BozenBolzano, 30th January-1st February 2013, 233–242. bu, press.

Bakker, LG, ECM Hoes-van Oeffelen, RCGM Loonen, and Jan LM Hensen. 2014. “User satisfaction and interaction with automated dynamic facades: A pilot study.” Building and Environment 78:44–52.

Balvedi, Bruna Faitão, Enedir Ghisi, and Roberto Lamberts. 2018. “A review of occupant behaviour in residential buildings.” Energy and Buildings 174:495–505.

Bennetts, Helen, Larissa Arakawa Martins, Joost van Hoof, and Veronica Soebarto. 2020. “Thermal personalities of older people in South Australia: A personas-based approach to develop thermal comfort guidelines.” International journal of environmental research and public health 17 (22): 8402.

Bluyssen, Philomena. 2009. The indoor environment handbook: how to make buildings healthy and comfortable. Routledge.

Bluyssen, Philomena M, Christian Cox, Nadia Boschi, Marco Maroni, Gary Raw, CA Roulet, and Flavio Foradini. 2003. European project HOPE (health optimization protocol for energy- efficient buildings). TNO.

Bluyssen, Philomena M, Dadi Zhang, and Marco Ortiz. 2022. “Associations between self- reported IEQ stressors of students’ homes and self-reported rhinitis, stuffy nose, mi- graine and headache in student profiles.” Building and Environment, 109903.

Bluyssen, PM, C Roda, C Mandin, S Fossati, P Carrer, Y De Kluizenaar, VG Mihucz, E de Oliveira Fernandes, and J Bartzis. 2016. “Self-reported health and comfort in ‘modern’office buildings: first results from the European OFFICAIR study.” Indoor Air 26 (2): 298–317.

Bouckaert, Stéphanie, Araceli Fernandez Pales, Christophe McGlade, Uwe Remme, Brent Wanner, Laszlo Varro, Davide D’Ambrosio, and Thomas Spencer. 2021. “Net Zero by 2050: A Roadmap for the Global Energy Sector.”

Cao, Xiaodong, Xilei Dai, and Junjie Liu. 2016. “Building energy-consumption status world- wide and the state-of-the-art technologies for zero-energy buildings during the past decade.” Energy and buildings 128:198–213.

Carletti, Cristina, Fabio Sciurpi, Leone Pierangioli, Francesco Asdrubali, Anna Laura Pisello, Francesco Bianchi, Sara Sambuco, and Claudia Guattari. 2016. “Thermal and lighting effects of an external venetian blind: Experimental analysis in a full scale test room.” Building and Environment 106:45–56.

Carmody, John, Stephen Selkowitz, Eleanor Lee, Dariush Arasteh, and Todd Willmert. 2004. Window system for high-performance buildings.

Cellai, G, C Carletti, F Sciurpi, and S Secchi. 2014. “Transparent building envelope: windows and shading devices typologies for energy efficiency refurbishments.” In Building refurbishment for energy performance, 61–118. Springer.

Chamilothori, K, J Wienold, C Moscoso, B Matusiak, and M Andersen. 2022. “Subjective and physiological responses towards daylit spaces with contemporary façade patterns in vir- tual reality: Influence of sky type, space function, and latitude.” Journal of Environmental Psychology 82:101839.

Chamilothori, Kynthia, Jan Wienold, Claudia Moscoso, B Matusiak, and Marilyne Andersen. 2022. “Regional Differences in the Perception of Daylit Scenes across Europe Using Virtual Reality. Part II: Effects of Façade and Daylight Pattern Geometry.” Leukos 18 (3): 316–340.

Charpentier, Victor, Forrest Meggers, Sigrid Adriaenssens, and Olivier Baverel. 2020. “Occupant-centered optimization framework to evaluate and design new dynamic shading typologies.” PloS one 15 (4): e0231554.

Cibse. 2007. Code for lighting. Routledge.

Cooper, Alan. 2004. Why high-tech products drive us crazy and how to restore the sanity.Sams Publishing.

De Dear, Richard. 2011. “Recent enhancements to the adaptive comfort standard in ASHRAE 55-2010.” In Proceedings of the 45th annual conference of the Architectural Science Association, Sydney, Australia, 16–19. Citeseer.

Despenic, Marija, Sanae Chraibi, Tatiana Lashina, and Alexander Rosemann. 2017. “Lighting preference profiles of users in an open office environment.” Building and Environment 116:89–107.

Economidou, Marina, Bogdan Atanasiu, Chantal Despret, Joana Maio, Ingerborg Nolte, Oliver Rapf, J Laustsen, P Ruyssevelt, D Staniaszek, D Strong, et al. 2011. “Europe’s buildings under the microscope. A country-by-country review of the energy performance of buildings.”

Edwards, L, and P Torcellini. 2002. “Literature review of the effects of natural light on building occupants.” Energies.

Eijkelenboom, Annemarie, and Philomena M Bluyssen. 2020. “Profiling outpatient staff based on their self-reported comfort and preferences of indoor environmental quality and social comfort in six hospitals.” Building and Environment 184:107220.

Eisazadeh, Nazanin, Karen Allacker, and Frank De Troyer. 2019. “Impact of Window Systems on Daylighting Performance, Visual Comfort and Energy Efficiency in Patient Rooms.” In IBPSA INTERNATIONAL CONFERENCE, 16:1207–1215.

Emmerich, Steven John, Timothy P McDowell, Wagdy Anis, et al. 2005. Investigation of the impact of commercial building envelope airtightness on HVAC energy use. US Department of Commerce, National Institute of Standards / Technology.

Eskin, Nurdil, and Hamdi Türkmen. 2008. “Analysis of annual heating and cooling energy requirements for office buildings in different climates in Turkey.” Energy and buildings 40 (5): 763–773.

Fabi, Valentina, Giorgia Spigliantini, and Stefano Paolo Corgnati. 2017. “Insights on smart home concept and occupants’ interaction with building controls.” Energy Procedia 111:759–769.

Favero, Matteo, Igor Sartori, and Salvatore Carlucci. 2021. “Human thermal comfort under dynamic conditions: An experimental study.” Building and Environment 204:108144.

Fisk, WJ. 1990. “Estimates of Improved Productivity and Health from Better Indoor Environment.” Indoor Air 7:696–698.

Fontoynont, Marc. 2014. Daylight performance of buildings. Routledge.

Frontczak, Monika, Stefano Schiavon, John Goins, Edward Arens, Hui Zhang, and Pawel Wargocki. 2012. “Quantitative relationships between occupant satisfaction and satisfaction aspects of indoor environmental quality and building design.” Indoor air 22 (2):

Galasiu, Anca D, and Jennifer A Veitch. 2006. “Occupant preferences and satisfaction with the luminous environment and control systems in daylit offices: a literature review.” Energy and buildings 38 (7): 728–742.

Gobain, Saint. 2016. “BUILDING THE BUSINESS CASE: Health, Wellbeing and Productivity in Green Offices.” Building and environment, 1–27.
Granzotto, Nicola, Federica Bettarello, Alessio Ferluga, Lucia Marsich, Chiara Schmid, Patrizio Fausti, and Marco Caniato. 2017. “Energy and acoustic performances of windows and their correlation.” Energy and Buildings 136:189–198.

Hartkopf, Volker, Azizan Aziz, and Vivian Loftness. 2020. “Facades and Enclosures: Building for Sustainability.” Sustainable Built Environments, 295–325.

Herzog, Thomas, Roland Krippner, and Werner Lang. 2012. Facade construction manual. Walter de Gruyter.

Heydarian, Arsalan, Evangelos Pantazis, Alan Wang, David Gerber, and Burcin Becerik-Gerber. 2017. “Towards user centered building design: Identifying end-user lighting preferences via immersive virtual environments.” Automation in Construction 81:56–66.

Hoffmann, Sabine, Christoph Jedek, and Edward Arens. 2012. “Assessing thermal comfort near glass facades with new tools.”

Huizenga, Charlie, Hui Zhang, Pieter Mattelaer, Tiefeng Yu, Edward A Arens, and Peter Lyons. 2006. “Window performance for human thermal comfort.”

IES, IES. 2012. “Standard LM-83-12. Approved Method: IES Spatial Daylight Autonomy (sDA) and Annual Sunlight Exposure (ASE).” Illuminating Engineering Society of North America.

Ihara, Takeshi, Arild Gustavsen, and Bjørn Petter Jelle. 2015. “Effect of facade components on energy efficiency in office buildings.” Applied Energy 158:422–432.

Kim, Dong Hyun, and Philomena M Bluyssen. 2020. “Clustering of office workers from the OFFICAIR study in The Netherlands based on their self-reported health and comfort.” Building and Environment 176:106860.

Klepeis, Neil E, William C Nelson, Wayne R Ott, John P Robinson, Andy M Tsang, Paul Switzer, Joseph V Behar, Stephen C Hern, and William H Engelmann. 2001. “The National Human Activity Pattern Survey (NHAPS): a resource for assessing exposure to environmental pollutants.” Journal of Exposure Science & Environmental Epidemiology 11 (3): 231–252.

Knaack, Ulrich, Tillmann Klein, Marcel Bilow, and Thomas Auer. 2014. Façades: principles of construction. Birkhäuser.

Ko, Won Hee, Michael G Kent, Stefano Schiavon, Brendon Levitt, and Giovanni Betti. 2022. “A window view quality assessment framework.” Leukos 18 (3): 268–293.

Konstantzos, Iason, and Athanasios Tzempelikos. 2017. “An online interactive tool to assess visual environment in offices with roller shades.” Energy Procedia 122:685–690.

Konstantzos, Iason, Athanasios Tzempelikos, and Ying-Chieh Chan. 2015. “Experimental and

simulation analysis of daylight glare probability in offices with dynamic window shades." Building and Environment 87:244–254.

Kumar, Dileep, Morshed Alam, Rizwan Ahmed Memon, and Bilawal Ahmed Bhayo. 2022. "A critical review for formulation and conceptualization of an ideal building envelope and novel sustainability framework for building applications." Cleaner Engineering and Technology, 100555.

Lan, Li, Pawel Wargocki, David Peter Wyon, and Zhiwei Lian. 2011. "Effects of thermal discomfort in an office on perceived air quality, SBS symptoms, physiological responses, and human performance." Indoor air 21 (5): 376–390.

Lee, Jong-Uk. 2021. "IEA, World Energy Outlook 2020." KEPCO Journal on Electric Power and Energy 7 (1): 25–30.

Liang, Han-Hsi, Chen-Peng Chen, Ruey-Lung Hwang, Wen-Mei Shih, Shih-Chi Lo, and Huey- Yan Liao. 2014. "Satisfaction of occupants toward indoor environment quality of certified green office buildings in Taiwan." Building and Environment 72:232–242.

Lim, Yaik-Wah, Mohd Zin Kandar, Mohd Hamdan Ahmad, Dilshan Remaz Ossen, and Aminatuzuhariah Megat Abdullah. 2012. "Building façade design for daylighting quality in typical government office building." Building and Environment 57:194–204.

Luna-Navarro, Alessandra. 2021. "Novel methods for capturing the multi-domain influence of the façade on occupant environmental perception and interaction." PhD diss., University of Cambridge.

Masoso, Okatoseng Tsametse, and Louis Johannes Grobler. 2010. "The dark side of occupants' behaviour on building energy use." Energy and buildings 42 (2): 173–177.
McMullan, Randall. 2017. Environmental science in building. Bloomsbury Publishing.

Meerbeek, Bernt, Marije te Kulve, Tommaso Gritti, Mariëlle Aarts, Evert van Loenen, and Emile Aarts. 2014. "Building automation and perceived control: A field study on motorized exterior blinds in Dutch offices." Building and Environment 79:66–77.

Minyoung, KWON. 2020. "Energy-Efficient Office Renovation: Developing design principles based on user-focused evaluation." A+ BE| Architecture and the Built Environment, no. 01, 1–244.

Mulville, Mark, Nicola Callaghan, and David Isaac. 2016. "The impact of the ambient environment and building configuration on occupant productivity in open-plan commercial offices." Journal of Corporate Real Estate.

Nabil, Azza, and John Mardaljevic. 2006. "Useful daylight illuminances: A replacement for daylight factors." Energy and buildings 38 (7): 905–913.

NEN. 2021. "Blinds and shutters - Thermal and visual comfort - Performance characteristics and classification." CEN, 1–45.

Norman, Donald A. 1988. The psychology of everyday things. Basic books.

Ortiz, Marco A, and Philomena M Bluyssen. 2019. "Developing home occupant archetypes: First results of mixed-methods study to understand occupant comfort behaviours and energy use in homes." Building and Environment 163:106331.

Ortiz, Marco A, and Philomena M Bluyssen. 2022. “Profiling office workers based on their self-reported preferences of indoor environmental quality and psychosocial comfort at their workplace during COVID-19.” Building and Environment 211:108742.

Osterhaus, Werner KE. 2005. “Discomfort glare assessment and prevention for daylight applications in office environments.” Solar Energy 79 (2): 140–158

Ozel, Meral. 2019. “Influence of glazing area on optimum thickness of insulation for different wall orientations.” Applied Thermal Engineering 147:770–780.

Pastore, Luisa, and Marilyne Andersen. 2022. “The influence of façade and space design on building occupants’ indoor experience.” Journal of Building Engineering 46 (7): 103663.

Patrıécio, Jorge, and Luıés Bragança. 2004. “The contribution of roller shutters to noise insulation of façades.” Building Acoustics 11 (4): 309–324.

Pérez-Lombard, Luis, José Ortiz, and Christine Pout. 2008. “A review on buildings energy consumption information.” Energy and buildings 40 (3): 394–398.

Pilechiha, Peiman, Mohammadjavad Mahdavinejad, Farzad Pour Rahimian, Phillippa Carnemolla, and Saleh Seyedzadeh. 2020. “Multi-objective optimisation framework for designing office windows: quality of view, daylight and energy efficiency.” Applied Energy 261:114356.

Pino, Alan, Waldo Bustamante, Rodrigo Escobar, and Felipe Encinas Pino. 2012. “Thermal and lighting behavior of office buildings in Santiago of Chile.” Energy and Buildings 47:441–449.

Pomponi, Francesco, Poorang AE Piroozfar, Ryan Southall, Philip Ashton, and Eric RP Farr. 2016. “Energy performance of Double-Skin Façades in temperate climates: A systematic review and meta-analysis.” Renewable and Sustainable Energy Reviews 54:1525–1536.

Pruitt, John, and Tamara Adlin. 2010. The persona lifecycle: keeping people in mind through- out product design. Elsevier.

Reinhart, Christoph F, and Jan Wienold. 2011. “The daylighting dashboard–A simulation- based design analysis for daylit spaces.” Building and environment 46 (2): 386–396.

Roelofsen, Paul. 2002. “The impact of office environments on employee performance: The design of the workplace as a strategy for productivity enhancement.” Journal of facilities Management.

Ruck, Nancy, Ø Aschehoug, and Sirri Aydinli. 2000. “Daylight buildings. A source book on daylighting systems and components.”

Sadeghi, Seyed Amir, Seungjae Lee, Panagiota Karava, Ilias Bilionis, and Athanasios Tzempelikos. 2018. “Bayesian classification and inference of occupant visual preferences in daylit perimeter private offices.” Energy and Buildings 166:505–524.

Sakellaris, Ioannis A, Dikaia E Saraga, Corinne Mandin, Célina Roda, Serena Fossati, Yvonne De Kluizenaar, Paolo Carrer, Sani Dimitroulopoulou, Victor G Mihucz, Tamás Szigeti, et al. 2016. “Perceived indoor environment and occupants’ comfort in European “modern” office buildings: The OFFICAIR study.” International journal of environmental research and public health 13 (5): 444.

Sant'Anna, DO, PH Dos Santos, NS Vianna, and MA Romero. 2018. "Indoor environmental quality perception and users' satisfaction of conventional and green buildings in Brazil." Sustainable Cities and Society 43:95–110.

Shahid, Hidayat, and David Naylor. 2005. "Energy performance assessment of a window with a horizontal Venetian blind." Energy and Buildings 37 (8): 836–843.

Sokol, Natalia, Justyna Martyniuk-Peczek, Barbara Matusiak, Claudia Naves David Amorim, Marta Waczynska, Julia Kurek, Natalia Giraldo Vasquez, Sergio Sibilio, Julia Resende Kanno, Michelangelo Scorpio, et al. 2023. "'Personas for lighting'. Three methods to develop personas for the indoor lighting environment." Energy and Buildings 278:112580.

Sugimoto, Masashi, Fan Zhang, Noriko Nagata, Kota Kurihara, Seiro Yuge, Makoto Takata, Koji Ota, and Seiji Furukawa. 2020. "Components of comfort in the office and its individual differences." In 2020 14th International Symposium on Medical Information Communication Technology (ISMICT), 1–6. IEEE.

Tabadkani, Amir, Astrid Roetzel, Hong Xian Li, and Aris Tsangrassoulis. 2021. "A review of occupant-centric control strategies for adaptive facades." Automation in Construction 122:103464.

Taghizade, Katayoon, Azin Heidari, and Esmatullah Noorzai. 2019. "Environmental impact profiles for glazing systems: strategies for early design process." Journal of Architectural Engineering 25 (2): 04019005.

Tan, Yutong, Jinqing Peng, Yimo Luo, Jing Gao, Zhengyi Luo, Meng Wang, and Dragan C Curcija. 2022. "Parametric study of venetian blinds for energy performance evaluation and classification in residential buildings." Energy 239:122266.

Tvedebrink, Tenna Doktor Olsen, and Andrea Jelic. 2018. "Getting under the (ir) skin: Applying personas and scenarios with body-environment research for improved understanding of users' perspective in architectural design." Persona Studies 4 (2): 5–24.

eitch, Jennifer Ann, and Anca D Galasiu. 2011. The physiological and psychological effects of windows, daylight, and view at home. National Research Council of Canada Ottawa, ON, Canada.

Weng, Jiantao, Yuhan Zhang, Zefeng Chen, Xiaoyu Ying, Wei Zhu, and Yukai Sun. 2023. "Field Measurements and Analysis of Indoor Environment, Occupant Satisfaction, and Sick Building Syndrome in University Buildings in Hot Summer and Cold Winter Regions in China." International Journal of Environmental Research and Public Health 20 (1): 554.

Wienold, Jan, Francesco Frontini, Sebastian Herkel, and Sandra Mende. 2011. "Climate based simulation of different shading device systems for comfort and energy demand." In 12th Conference of International Building Performance Simulation Association, 14–16.

Wu, Hang, Dengjia Wang, Yanfeng Liu, and Yingying Wang. 2017. "Study on the effect of building envelope on cooling load and life-cycle cost in low latitude and hot-humid climate." Procedia Engineering 205:975–982.

Yoshino, Hiroshi, Tianzhen Hong, and Natasa Nord. 2017. "IEA EBC annex 53: Total energy use in buildings—Analysis and evaluation methods." Energy and Buildings 152:124–136

Reflection

1. Relation between graduation (project) topic, master track (A,U,BT,LA,MBE), and master programme (MSc AUBS).

The graduation top addresses “User Archetypes for Façade Technologies”. In order to understand the user Archetypes require, the research takes a multi-disciplinary approach. This requires an in depth inquiry into façade technologies (shading systems in particular), daylighting and thermal comfort of spaces and an overall framework of user perception and behaviour. This requires the integration of Façade design and Engineering group with the Building Physics and Services group. Which are two of the various research groups within the AE+T department at the Faculty of Architecture, TU Delft. Furthermore, in the next part of the research, Clustering and Statistical Analysis Techniques will be used to form the Archetypes as mentioned within the methodology. Hence, the research will be making use of Machine Learning Techniques and Simulation tools within the experiment phase. Hence, the computation design forms an integral part of the multi-disciplinary work-flow of the research project. The research conducted here relates also to the way in which designers could make decisions for occupants. By approaching the decision from the point of view of the building occupant, the research aims to put the occupant at the fore-front of the designers by means of a bottom up design approach. Hence, this multi-disciplinary research can assist in the design of innovative, comfortable and sustainable building envelopes.

2. Relevance of your graduation work in the larger social, professional and scientific framework.

Environmental Relevance

Urban environments and buildings undoubtedly contribute to global development, but they also present chances for transformation and are likely to serve as the pivot around which sustainable development may be realized in the future. When buildings are well planned, they can provide a setting that encourages behaviors that are economically, socially, and environmentally viable. Optimizing building performance requires a deep understanding of occupants’ behavior and preferences (Anik, Gao, and Meng 2022). In Europe, office buildings are the second largest category of the non-residential building stock with a floor space corresponding to one-quarter of the total non-residential area. During the last 20 years, the electricity consumed by the non-residential buildings has increased by 74 percent (Economidou et al. 2011).Hence, there is a need to approach the building performance through energy assessment of façade technologies. Building façades have always been important in the fields of indoor environmental quality (IEQ) and energy research due to their significant responsibility for ensuring suitable indoor environmental conditions. Currently, the design of façade technologies is achieved on the basis of Multi-domain performance and energy saving. The research pushes for energy performance of facade technologies in symbiosis with occupant comfort.

Social Relevance

The relation between the design of office spaces and their impact on occupant comfort and well being has always been researched (P. Bluyssen et al. 2016) (Mulville, Callaghan, and Isaac 2016) (Al Horr et al. 2016) (Minyoung 2020). Although user perspectives are an important part of worldwide green building grading systems, which address these studies, there are few guidelines and resources that concentrate on user happiness in building design (Minyoung 2020). The relation between user and spaces they use has not been understood well due to the subjectivity of spatial perception. Users could be influenced by the design in ways that are not necessarily the most energy efficient. That is not to forget the difference in opinion on the various Indoor environmental quality aspects of a space. This may impact the performance of the facade in Post Occupancy Scenarios due to mis operation of office and facade systems by occupants. Additionally, the prevalence of sick building syndrome (SBS) symptoms, or acute health issues among office workers, has been connected to characteristics of buildings facade and interior settings. These signs and symptoms include skin, nose, and eye irritation

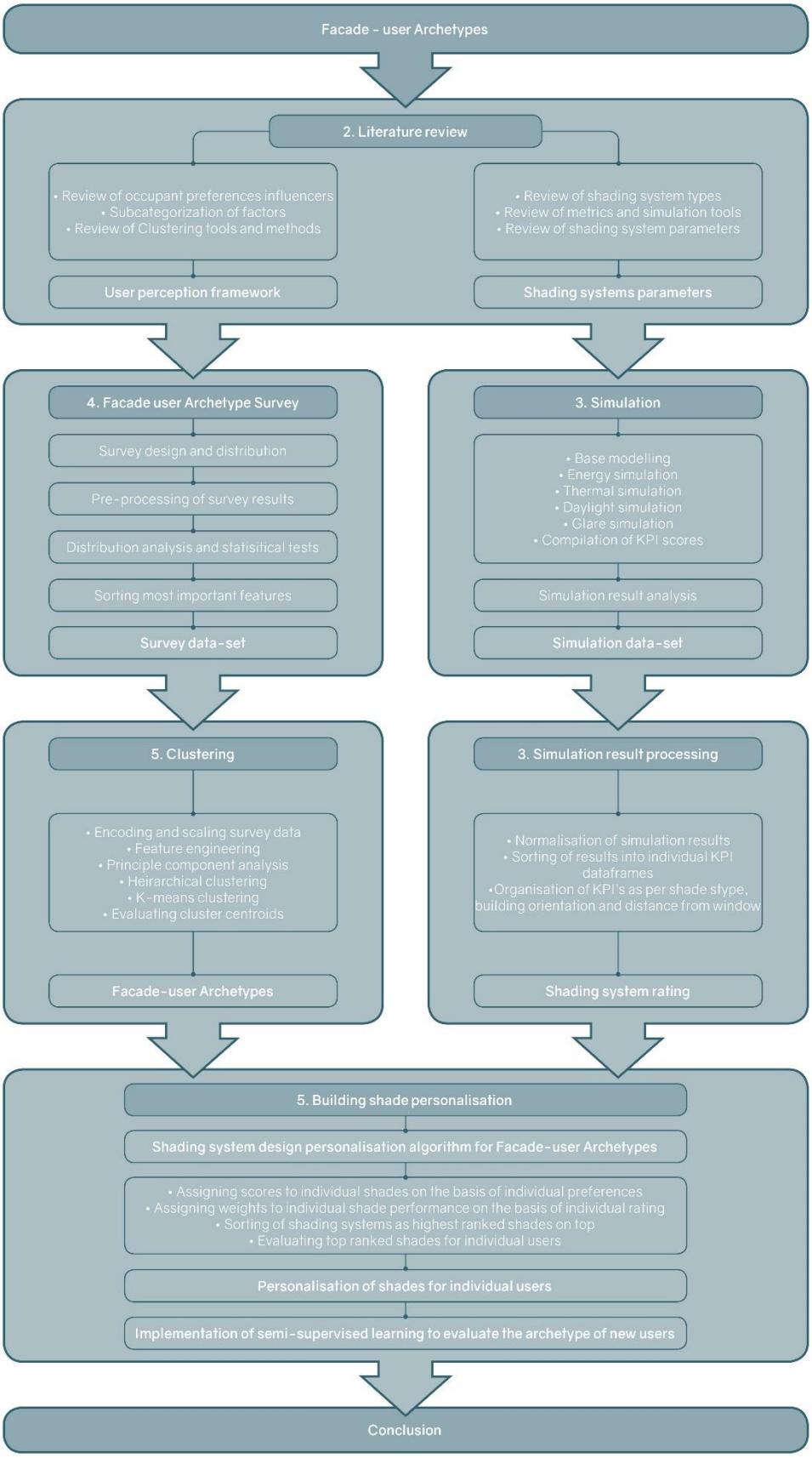
as well as headache, exhaustion, and trouble breathing (Fisk 1990). Conversely, occupants who often enjoy their office and its façade may have a positive perception of their overall comfort for a wider range of environmental circumstances due to seasonal Forgiveness Factor and the pleasantness of a space as well as the appreciation of a façade have a strong correlation (Pastore and Andersen 2022). In order to achieve this, there is need to address two factors: user perspective on the one hand, and a rich body of knowledge from various body-environment research disciplines can be interlinked through the facade-user archetype method in order to help encourage in-depth immersion in user perspective understanding of diverse user groups in complex building projects like healthcare environments. By accommodating the needs of the user, the research moves in the direction of health and well-being of building occupants.

Scientific Relevance

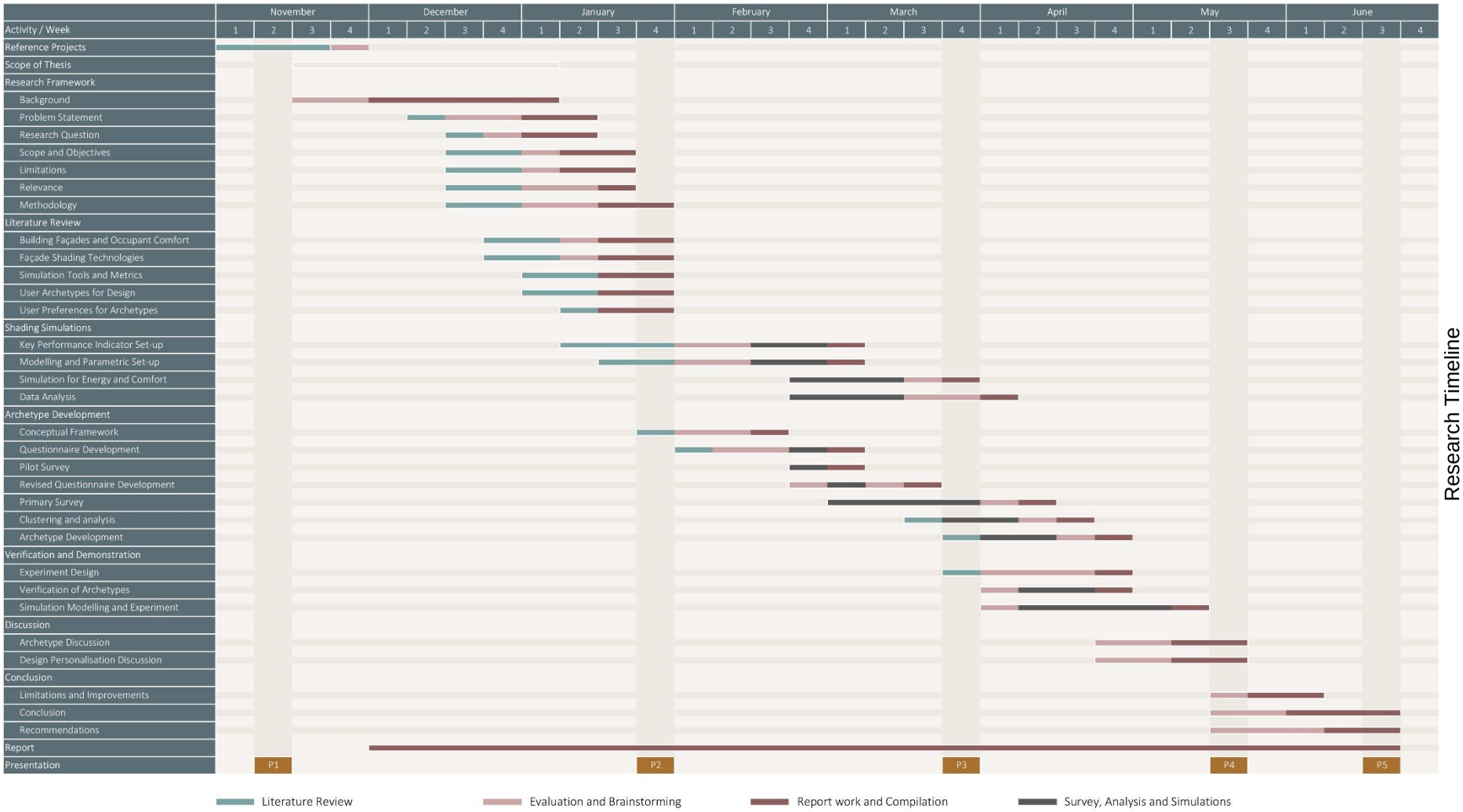
According to Yoshino, Hong, and Nord (2017), building energy consumption is mainly influenced by six factors: (1) climate, (2) building envelope, (3) building services and energy systems, (4) building operation and maintenance, (5) occupant activities and behavior and (6) indoor environmental quality provided. Building envelopes are a primary cause for concern not only because of their design but also due to how they are interconnected with occupant behavior and the indoor environmental quality. Often, Facade Shading technologies provide the occupants to adapt the indoor environmental quality of a space to restore their comfort and environmental satisfaction. In other situations, fixed shading systems serve well to provide shade through the year in regions with adequate daylight hours through the year. Occupant preferences towards shading systems can help in solving complex design scenarios as a shading system incorporated without occupant preference might not be operated as desired leading to inefficient energy performance of the facade systems. Hence, it is extremely important to account for individual occupant preference while designing to achieve optimal indoor comfort and positive perception of the designed shades. A statistical analysis of the user before design is almost impossible due to the uncertainty of the actual users. This could be due to multiple reasons. First, being user centered is not natural as our natural tendency is to be self centered, which translates to taking an approach to design based on our own wants and needs. Second, users are varied and complicated. It takes effort to understand their needs, behaviors and desires. And often, pleasing a certain set of users leads to conflicts with other users' desires. Third, Those doing the market research are not the ones designing usually. If the information on users is not available or difficult to understand, design teams go ahead and design products they think users would like (Pruitt and Adlin 2010). In "The inmates are running the asylum", Cooper mentions that If you want to create a product that satisfies a broad audience of users, logic will tell you to make it as broad in its functionality as possible to accommodate the most people. Logic is wrong. You will have far greater success by designing for a single person (Cooper 2004). By understanding the user set as a set of various clusters of Archetypes, we can better understand the user set along with their preferences. Hence, Personas and archetypes have huge opportunities of becoming a part of the design process by giving the designer an insight into the background, perceptions, behaviors, aspirations and requirements.

Professional Relevance

Within the realm of Façade Design and Engineering, a lot of analysis is conducted on the thermal and visual performance of façade technologies. By means of this research project, there is an attempt to rethink the design process of facades and building envelopes in the future. By means of imagining a User-Centered Design methodology, the research attempts to provide a step within the workflow for façade designers and building physics engineers to verify occupant preferences and behaviours in order to ensure correct handling of façade technologies. Finally, façade manufacturers currently design façade technologies for the market which may or may not provide comfort to users considering various factors. This research is a step towards exploring how existing façade technologies could be personalised for users in order to provide the expected comfort.



Research Outline


November
December
January
February
March
April
May
June
Activity / Week
1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
Reference Projects
Scope of Thesis
Research Framework
Background
Problem Statement
Research Question
Scope and Objectives
Limitations
Relevance
Methodology
Literature Review
Building Façades and Occupant Comfort
Façade Shading Technologies
Simulation Tools and Metrics
User Archetypes for Design
User Preferences for Archetypes
Shading Simulations
Key Performance Indicator Set-up
Modelling and Parametric Set-up
Simulation for Energy and Comfort
Data Analysis
Archetype Development
Conceptual Framework
Questionnaire Development
Pilot Survey
Revised Questionnaire Development
Primary Survey
Clustering and analysis
Archetype Development
Verification and Demonstration
Experiment Design
Verification of Archetypes
Simulation Modelling and Experiment
Discussion
Archetype Discussion
Design Personalisation Discussion
Conclusion
Limitations and Improvements
Conclusion
Recommendations
Report
Presentation
P1
P2
P3
P4
P5
Literature Review
Evaluation and Brainstorming
Report work and Compilation
Survey, Analysis and Simulations
Research Timeline