The Influence of Indoor Environmental Quality on Perceived Quality of Learning in Classrooms for Higher Education

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ABSTRACT

Background and aim – In this study, it is pre-supposed that the indoor environmental conditions of classrooms can contribute to the quality of the educational process. Thermal, acoustic and visual conditions and indoor air quality (IAQ) may be extremely supportive in order to support the in-class tasks of teachers and students. This study explores the influence of these conditions on the perceived comfort and quality of learning of students in higher education.

Methodology – In a case study design, the actual IEQ of 34 classrooms which are spread over four school buildings in North Netherlands and 276 related student perceptions were collected. The measurements consisted of in situ physical measurements. At the same moment the perceived indoor environmental quality (PIEQ) and the perceived quality of learning (PQL) of students were measured with a questionnaire.

Results – Observed are high carbon dioxide concentrations and high background noise levels. A relation was observed between perceived acoustic and visual conditions, IAQ, and the PQL indicating that a poor IEQ affects the PQL. A linear regression analyses showed that in this study the perceived impact on the quality of learning was mainly caused by perceived acoustic comfort.

Originality – With the applied innovative measuring instrument it is possible to measure both the actual IEQ as well as the PIEQ and PQL. This method can also be used to assess a reference and intervention condition.

Practical or social implications – The applied measuring instrument provides school management with information about the effectiveness of improved IEQ and students' satisfaction, which can be the basis for further improvement.

Type of paper – Research paper.

KEYWORDS

Acoustic comfort, indoor air quality, indoor environment, thermal comfort, quality of learning, cognitive performance, visual comfort.

INTRODUCTION

This study explores the influence of classrooms' indoor environmental quality (IEQ) on the perceived quality of learning of users in higher education. In total, four factors, e.g. academic environment, learning community, safety, and institutional environment influence the educational outcomes of students and is often referred to as the school climate (Wang & Degol, 2016). The quality of learning, which is part of the schools' institutional environment, can influence students' educational outcomes positively. General environmental psychology literature teaches us that teachers and students respond to the experienced IEQ in a cognitive, emotional, and physiological way, which might differ from person to person (Bitner, 1992). This behaviour determines – partly - the extent of interactions between teacher and student which influences educational outcomes, i.e. the quality of learning. In this study, the possible influence of the actual IEQ and the perceived indoor environmental quality (PIEQ) on the perceived quality of learning (PQL) was examined.

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This study focusses on the IEQ, which is a system of the indoor air quality (IAQ) and thermal, lighting, and acoustic conditions (Frontczak & Wargocki, 2011). Mendell and Heath (2005) relate a poor IEQ to discomfort and distraction, which can impair the performance of students. One of the main causes of impaired performance among children are the poor acoustical conditions and there is an urgent need for acoustical measures in schools (Bluyssen, Zhang, Kurvers, Overtoom, & Ortiz-Sanchez, 2018). A comfortable and healthy IEQ in classrooms can also potentially influence teaching and learning positively (Dawson & Parker, 1998), which in turn increases the likelihood of a better academic achievement of students. Therefore, it is assumed that when students feel comfortable, they perform cognitively better (Xiong et al., 2018). Human cognitive reactions can be measured with the use of questionnaires and these reactions can illuminate the perceived quality of learning of students in higher education (Ashrafi & Naeini, 2016; Mongkolsawat, Marmot, & Ucci, 2014).

STUDY DESIGN, PARTICIPANTS, PROCEDURES AND ANALYSES

In this case study, we analysed the influence of the actual IEQ in classrooms for higher education. These classrooms are located in four school buildings in the Northern part of the Netherlands. With the use of a self-composed questionnaire, students' perceptions were measured. The in-class physical measurements consisted of air temperature, relative humidity, carbon dioxide concentration, ambient sound pressure (at moment when the teachers speak and when they were quit), and illuminance level. Appendix 1 presents the measured physical indoor environmental parameters, the applied measuring equipment and the accuracy of this equipment. The personal characteristics and the perceived IAQ, thermal, acoustic and visual comfort, and the PQL was collected with a self-composed questionnaire. For this questionnaire we used relevant publications (Mongkolsawat et al., 2014; Gentile, Goven, Laike, & Sjoberg, 2018; Corgnati, Filippi, & Viazzo, 2007; Choi, Shin, Kim, Chung, & Suk, 2019). On forehand, we analysed the face and content validity of all selected statements for the PIEQ. Therefore, experts of The Hague University of Applied Sciences (UAS), DGMR Advisors for Construction, Industry, Traffic and Environment and Nijeboer-Hage Technical Advisors assessed all statements. Appendix 2 shows the statements which were analysed by the experts, the advice given, and which statements were used to determine the PIEQ. In addition, we translated all statements into Dutch and this translation has been modified by a bilingual expert. In addition, we set up an online survey tool (Enalyzer) which allowed respondents to fill in the bilingual questionnaire, with the use of a device. All the statements were evaluated on a 5-point-Likert scale ranging from strongly disagree, disagree, neutral, agree and strongly agree. Before the start of the observed lecture, first year students of the School of Facility Management of the Hanze University of Applied Sciences (UAS) were carefully instructed how to perform the physical measurements. A senior researcher of the Hanze UAS supervised these students during the in-class measurements.

In February and March 2020, 34 classrooms were examined by 159 first year students. The classrooms differed in size and capacity and varied from 35 to 118 persons. The Facility Management Department of the Hanze UAS informed all involved teachers on forehand about the research, the participation of the first-year students during the lecture, and the importance to collaborate in this study. No teacher has objected to the research, in a few cases the observation schedule was slightly adjusted to fit in to the time schedule of the teacher.

Multiple physical measurements were performed in a classroom at different positions, e.g. at the front, in the middle and at the back. These measurements were performed on three moments during the lecture, at the beginning of the lecture, after 20 minutes, and after 40 minutes after the start of the lecture. For this study, we used the physical measurements which were collected after about 40 minutes. After approximately 45 minutes from the start of the lecture, the first-year students asked all students present if they want to participate in the study. We have chosen for a period of 45 minutes because after 45 minutes normally there is a break, or the lecture is finished, and this period is long enough for thermal adaptation (Mishra, Derks, Kooi, Loomans, M G L C, & Kort, 2017).

After data collection, we exported the data from the survey tool into SPSS. Furthermore, we recoded all negative formulated statements and performed a Cronbach's alpha analyses to assess the internal validity of the statements addressing the perceived perceived IAQ (PIAQ), thermal comfort (PTC), acoustic comfort (PAC), visual comfort (PVC), and PQL. In addition, average scores of the physical measurements, observed by a minimum of two and a maximum of four first year students, of a classroom were calculated and combined with the data of perceived comfort and PQL. Finally, we analysed correlations between the perception scales and the physical measurements and between the perceptions scales using the Pearson correlation coefficient. To determine the contribution of all indoor environmental factors to the PQL, we performed a multiple linear regression analysis. All statistical analyses were performed with IBM SPSS Statistics version 23.

RESULTS

Responses of 276 students were collected, who collaborated voluntarily in this study. The response rate was 37%. The mean age of the respondents was 22.2 years (SD 6.8 years) of which 50.4% was male. The Cronbach's Alpha analyses of all perception scales showed that all statements for perceived comfort and quality of learning, contributed to the reliability of the scales, except for one statement which addressed thermal comfort and was removed from the results. Appendix 2 shows the statements and the Cronbach's Alpha of the composed scales. The alpha value for the perception scales ranged from 0.73 to 0.88, showing that these scales have considerable reliability; therefore, we used the average perception scores of the five categories for further analyses. The highest perception score was for the PVC with an average score of 3.7 (scale from 1 to 5). The perception score of the PIAQ was rated the lowest with a score of 2.9. All observed indoor environmental parameters were within acceptable limits (NEN-EN 16798, 2019) except for the concentration carbon dioxide in ambient air and the average background noise level. The observed average air temperature at desk height of 22.2 °C and at floor height of 22.1 °C indicate that no vertical air temperature difference was observed. Furthermore, we analysed possible correlations between all measured IEQ parameters and perception scores. Table 1 presents all average perception scores, physical measurements and relevant Pearson's correlation coefficients.

Table 1 Actual IEQ scores, PIEQ scores and correlations.

				Pearson correlation				
		Mean	**SD**	**PIAQ**	**PTC**	**PAC**	**PVC**	**PQL**
Perceived indoor air quality	PIAQ	2.9[1]	.9	n/a	-.166**	.206**	-	.181**
Perceived thermal comfort	PTC	3.3[2]	.9	-.166**	n/a	-	-	.102
Perceived acoustic comfort	PAC	3.6[1]	.9	.206**	-	n/a	-	.306**
Perceived visual comfort	PVC	3.7[1]	.7	-	-	-	n/a	.229**
Perceived quality of learning	PQL	3.5[1]	.8	.181**	.102	.306**	.229**	n/a
Outdoor air temperature	T_{out}	5.2	2.4	-	.165**	-	-	-
Outdoor relative humidity	RH_o	80.7	12.0	-	-	-	-	-
Indoor air temperature at desk-top height	T_a	22.2	2.7	.186**	.149*	-	-	.062
Indoor air temperature at floor height	T_afl	22.1	2.8	.165**	.166**	-	-	.091
Indoor relative humidity	RH_i	39.8	5.8	-.152*	-.028	-	-	.008
Carbon dioxide concentration	CO_2	1219.7	454.6	-.027	.105	-	-	.144*
Sound pressure level when teacher speaks	SPL	58.1	11.0	-	-	-.066	-	-.043
Background noise when teacher is not speaking	BGN	41.4	13.6	-	-	.009	-	-.021
Ambient illuminance	E_{amb}	673.2	379.4	-	-	-	.042	-.038

*p≤ 0.05**p≤ 0.01***p≤ 0.001; -no relation was expected; [1] Score is between 1 (very poor) to 5 (very good); [2] Score is between 1 (very cold) to 5 (very warm)

In addition, we performed a multiple linear regression analyses to determine the influence of all perception scales, as independent variables, on the perceived quality of learning, as dependent variable. When the PQL was predicted it was found that PAC (Beta = 0.237, $p < .0001$) was the only significant predictor. The overall model fit was R^2 = 0.12.

DISCUSSION AND CONCLUSION

The observed CO_2 concentrations, with an average well above the threshold of 1200[1] ppm for classrooms (NEN-EN 16798, 2019) were high, indicating that the IAQ in the observed classrooms was poor. Although previous findings (Brink, Mobach, Loomans, & Kort, 2019) showed significant relations between CO_2 concentration and PIAQ, the current results do not confirm this relation, possible because not enough cases with good IAQ was observed. The average observed indoor air temperature of 22.2^{0}C is acceptable for most of the students, with an average perception score of 3.3, which is close to the neutral score of 3.0. This might explain that no relation was observed between PTC and PQL, although thermal comfort can potentially affect PQL negatively (Hoque & Weil, 2016). All other indoor environmental perception scores correlated with the PQL score, meaning that when the indoor environment factor was rated higher, also the PQL was higher. However, regression analyses showed that only the contribution of the perceived acoustic conditions was significant. The observed average background noise level of 41.4 dB(A) is high and might affect the speech intelligibility, which can influence the ability to hear the teachers voice negatively (Markides, 1989). Increased background noise, caused by i.e. ventilation systems in classrooms or students talking to each other, can affect students' mental and physical health negatively (Bluyssen et al., 2018; Persinger, Tiller, & Koren, 1999). Based on these findings we conclude that reducing background noise levels and reduced noise from other students can improve the acoustic comfort of students in classrooms significantly and will improve the perceived learning quality during lecture. Therefore, we advise school- and facility management to create an acoustic environment with background noise levels below 34 dB(A) (Cat. II EN 16798, 2019), in which students can concentrate well and are not distracted. Teachers can also contribute to improved acoustic conditions when they address students who talk to each other during lecture about their undesirable behaviour.

[1] The average observed outdoor concentration was 400 ppm.

REFERENCES

Ashrafi, S. E., & Naeini, H. S. (2016). Determination of effective factors on reduction of sick building syndrome in designing educational environments. *International Journal of Advanced Biotechnology and Research, 7*, 144-152.

Bitner, M. J. (1992). Servicescapes: The impact of physical surroundings on customers and employees. *Journal of Marketing, 56*(2), 57-71.

Bluyssen, P. M., Zhang, D., Kurvers, S., Overtoom, M., & Ortiz-Sanchez, M. (2018). Self-reported health and comfort of school children in 54 classrooms of 21 dutch school buildings. *Building and Environment, 138*, 106-123. doi:10.1016/j.buildenv.2018.04.032

Brink, H. W., Mobach, M. P., Loomans, M. G., & Kort, H. S. (2019). The effect of indoor air quality in Dutch higher education classrooms on students' health and performance. Paper presented at the *Joint Meeting of the International Societies of Exposure Science (ISES) and Indoor Air Quality and Climate (ISIAQ) 2019. Abstract Book: The Built, Natural, and Social Environments: Impacts on Exposures, Health and Well-Being,* 361-362.

Castro-Martínez, J. A., Roa, J. C., Benítez, A. P., & González, S. (2016). Effects of classroom-acoustic change on the attention level of university students. *Interdisciplinaria, 33*(2), 201-214. doi:10.16888/interd.2016.33.2.1

Choi, K., Shin, C., Kim, T., Chung, H. J., & Suk, H. J. (2019). Awakening effects of blue-enriched morning light exposure on university students' physiological and subjective responses. *Scientific Reports, 9*(1), 1-8. doi:10.1038/s41598-018-36791-5

Corgnati, S. P., Filippi, M., & Viazzo, S. (2007). Perception of the thermal environment in high school and university classrooms: Subjective preferences and thermal comfort. *Building and Environment, 42*(2), 951-959. doi:10.1016/j.buildenv.2005.10.027

Frontczak, M., & Wargocki, P. (2011). Literature survey on how different factors influence human comfort in indoor environments. *Building and Environment, 46*(4), 922-937. doi:10.1016/j.buildenv.2010.10.021

Gentile, N., Goven, T., Laike, T., & Sjoberg, K. (2018). A field study of fluorescent and LED classroom lighting. *Lighting Research & Technology, 50*(4), 631-650. doi:10.1177/1477153516675911

Hoque, S., & Weil, B. (2016). The relationship between comfort perceptions and academic performance in university classroom buildings. *Journal of Green Building, 11*(1), 108-117. doi:10.3992/jgb.11.1.108.1

Markides, A. (1989). Background noise and lip-reading ability. *British Journal of Audiology, 23*(3), 251-253. doi:10.3109/03005368909076507

McDonald, D. D., Wiczorek, M., & Walker, C. (2004). Factors affecting learning during health education sessions. *Clinical Nursing Research, 13*(2), 156-167. doi:10.1177/1054773803261113

Mendell, M. J., & Heath, G. A. (2005). Do indoor pollutants and thermal conditions in schools influence student performance? A critical review of the literature. *Indoor Air, 15*(1), 27-52. doi:10.1111/j.1600-0668.2004.00320.x

Mishra, A. K., Derks, M. T. H., Kooi, L., Loomans, M G L C, & Kort, H. S. M. (2017). Analysing thermal comfort perception of students through the class hour, during heating season, in a university classroom. *Building and Environment, 125*(11), 464-474. doi:10.1016/j.buildenv.2017.09.016

Mongkolsawat, D., Marmot, A., & Ucci, M. (2014). A comparison of perceived learning performance of Thai university students in fan-assisted naturally ventilated and air-conditioned classrooms. *Intelligent Buildings International, 6*(2), 93-111. doi:10.1080/17508975.2014.893863

NEN-EN 16798. (2019). *Energy performance of buildings - ventilation for buildings - part 1 - module M1-6.* (No. ICS 91.120.10; 91.140.01). Brussels: European Committee For Standardization.

Persinger, M. A., Tiller, S. G., & Koren, S. A. (1999). Background sound pressure fluctuations (5 dB) from overhead ventilation systems increase subjective fatigue of university students during three-hour lectures. *Perceptual and Motor Skills, 88*(2), 451-456. doi:10.2466/PMS.88.2

Wang, M., & Degol, J. L. (2016). School climate: A review of the construct, measurement, and impact on student outcomes. *Educational Psychology Review, 28*(2), 315-352. doi:10.1007/s10648-015-9319-1

Xiong, L., Huang, X., Li, J., Mao, P., Wang, X., Wang, R., & Tang, M. (2018). Impact of indoor physical environment on learning efficiency in different types of tasks: A 3 x 4 x 3 full factorial design analysis. *International Journal of Environmental Research and Public Health, 15*(6), 1256. doi:10.3390/ijerph15061256

APPENDIX 1: INDOOR ENVIRONMENTAL PARAMETERS, SYMBOLS AND DESCRIPTION OF MEASURING

Variable	Symbol	Description Of Measuring
Outdoor air temperature	T_{out}	The outside temperature and the outside humidity was derived from a reliable open source, www.weerplaza.nl, at the moment the occupant was questioned
Indoor air temperature at desktop height	T_a	Air temperature in degrees Celcius (°C) and is measured with an TESTO 610 temperature and humidity sensor at desktop height (average 0.7m), accuracy ±0.5 °C @-10 to +50 °C
Indoor air temperature at floor	$T_a$fl	Air temperature in degrees Celcius (°C) and is measured with an TESTO 610 temperature and humidity sensor at desktop height (average 0.7m), accuracy ±0.5 °C @-10 to +50 °C
Indoor relative humidity	RH_i	Indoor relative humidity in percentage (%) and is measured with a TESTO 610 temperature and humidity sensor at desktop height (average 0.7m), accuracy ±2.5 % RH_i @ 5 to 95 %RH_i
Background noise when teacher is not speaking	BGN	Average sound pressure level in dB(A) over a period of 45 seconds and is measured with a Velleman DEM201, accuracy +/- 1.4 dB 94 dB @ 1 kHz
Sound pressure level when teacher speaks	SPL	Average sound pressure level in dB(A) over a period of 45 seconds and is measured with a Velleman DEM201, accuracy +/- 1.4 dB 94 dB @ 1 kHz
Carbon dioxide concentration	CO2	Parts per million carbon dioxide concentration (ppm CO2) is measured with a Atal ENV-MB350NV carbon dioxide sensor on the desktop, accuracy ±30 ppm + 5% of the actual reading
Ambient illuminance	E_{amb}	Illuminance level in Lux and is measured with a VOLTCRAFT MS-1300, accuracy ± 5% + 10 digits @ < 10.000 lux

APPENDIX 2: PERCIEVED INDOOR ENVIRONEMENTAL STATEMENTS AND CRONBACH'S ALPHAS

See footnote to Table for explanation of all variables used

English statement	Dutch statement	Advice	RS
Perceived Thermal Comfort (PTC) α = 0.73			
It is too cold in here	Het is hier nu te koud	OK	R
It is too hot in here	Het is hier nu te warm	OK	
I have cold feet	Ik heb koude voeten	OK	R
I have warm feet	Ik heb warme voeten	OK	
I have cold hands	Ik heb koude handen	OK	R
I have warm hands	Ik heb warme handen	OK	
There is a draught in here	Het tocht hier	OK	R
I am troubled by a cold window or wall	Ik heb last van een koud raam of koude muur	OK	R
I am troubled by a warm radiator	Ik heb last van een warme radiator	DE[1]	n/a
I am stuffy	Ik heb het benauwd	OK	
Perceived Indoor Air Quality (PIAQ) α = 0.81			
There is some stale air in here	Er hangt hier een muffe lucht	OK	R
There is a lot of fresh air in here	Er is hier veel frisse lucht	OK	
The air is dusty in here	De lucht is hier stoffig	OK	R
The classroom is properly ventilated	Het klaslokaal is goed geventileerd	OK	
There is a bad smell in here	Het stinkt hier	OK	R

Perceived Acoustic Comfort (PAC) α = 0.88			
Students speaking outside the classroom interfere with my ability to hear in the classroom	Studenten die buiten het klaslokaal praten, verstoren mijn vermogen om te horen in het klaslokaal	OK	R
Students moving and mingling in the classroom interfere with my ability to hear in the classroom	Lopende of bewegende studenten in het klaslokaal verstoren mijn vermogen om te horen in het klaslokaal	OK	R
Noise from the instrumentation used in the classroom interfere with my ability to hear in the classroom	Lawaai van de apparatuur in de klas verstoort mijn vermogen om te horen in het klaslokaal	OK	R
Noise from people or instrumentation outside the classroom but inside the building interfere with my ability to hear in the classroom	Lawaai van mensen of apparatuur buiten het klaslokaal, maar in het gebouw verstoort mijn vermogen om te horen in het klaslokaal	OK	R
I experience prolonged noise disturbance	Ik ervaar langdurig geluidsoverlast	OK	R
I experience short noise disturbance	Ik ervaar kortdurende geluidsoverlast	OK	R
Noises that occur only once interfere with my ability to hear in the classroom	Geluiden die slechts eenmaal optreden verstoren mijn vermogen om te horen in het klaslokaal	OK	R
Noises that occur occasionally interferes with my ability to hear in the classroom	Geluiden die af en toe optreden verstoren mijn vermogen om te horen in het klaslokaal	OK	R
The noises I hear in the classroom bother me	De geluiden die ik hoor in het klaslokaal storen me	OK	R
The noise disturbs my concentration	Het geluid verstoort mijn concentratie	OK	R
Perceived Visual Comfort (PVC) α = 0.75			
The visual comfort in the classroom is very bad	Het visueel comfort in het klaslokaal is zeer slecht	OK	R
The illumination provided by artificial sources in the classroom compared to the shape of the classroom itself (geometry of the classroom) is inadequate	De verlichtingssterkte van het kunstlicht in de klas in vergelijking met de vorm van de klas zelf (geometrie van het klaslokaal) is onvoldoende	DE[2]	n/a
The distribution of the light in the classroom is sufficient	De verdeling van het licht in het klaslokaal is voldoende	NA	
In the classroom the light rarely flickers	In het klaslokaal is zelden sprake van schitteringen	OK	R
In the classroom, I frequently experience unpleasant color sensations	In het klaslokaal ervaar ik regelmatig een onaangename weergave van kleuren	OK	R
The illumination provided by projectors appears to be inadequate	De verlichtingssterkte van projectoren is ontoereikend	OK	R
In the classroom, I frequently experience annoying reflections produced from the outside	In het klaslokaal ervaar ik regelmatig hinderlijke reflecties van buitenaf	OK	R
In the classroom, windows create dark areas	Ramen zorgen voor donkere gebieden (schaduwen) in het klaslokaal	OK	R
I can see well in this light	Ik kan goed zien in dit licht	OK	
It is dark in the classroom	Het is donker in dit klaslokaal	OK	R

The light seeping through windows appears to be inadequate	Er komt onvoldoende daglicht binnen door de ramen	DE[3]	n/a
Perceived Quality of Learning (PQL) α = 0.85			
I was able to concentrate well during the lecture	Ik kon mij goed concentreren tijdens de les	OK	
I was very alert during the lecture	Ik was zeer alert tijdens de les	OK	
I was very productive during the lecture	Ik was zeer productief tijdens de les	OK	
I can remember the content of the lecture well	Ik kan de lesstof goed onthouden	OK	
I was able to solve complicated problems during lecture well	Ik kon ingewikkelde vraagstukken makkelijk oplossen tijdens de les	OK	
I was able to understand the lecture well	Ik kon de les goed begrijpen	OK	
I was able to read well during the lecture	Ik kon goed lezen tijdens de les	OK	
I was able to type well during the lecture	Ik kon goed typen tijdens de les	OK	

RS= Reverse score for calculating alpha and average perception score
OK=Statement is relevant
DE=Statement is deleted
NA=Statement needed adjustment
1) Expert stated that many classrooms in The Netherlands do not have radiators
2) Expert advised to rephrase this item because this statement is difficult to understand
3) Expert indicated that this question is not valid because there is always a combination of daylight and artificial light in the classroom, so the amount of daylight cannot be assessed by the respondent

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Deltapremie

The 'Deltapremie' or Delta Prize is a new leading research prize in the Netherlands focusing on practice-oriented research by professors. The prize is developed for professors who have managed to repeatedly make a special difference with the social impact of their research over the years. It shows where practice and research can come together in an innovative way. Practice-oriented research has acquired a solid place in Dutch society. Almost 700 professors and more than 3,000 teacher-researchers are currently involved. The starting point of the research is always to find solutions for practice-based problems, also by partnering with practice. In this way, practice-oriented research provides applicable solutions to societal challenges.

An independent selection committee selected the winners. The committee consisted of six experts from Erasmus University Rotterdam, Innofest, Delft University of Technology, Netherlands Study Centre for Technology Trends, and the Association of Netherlands Municipalities. In the report the selection committee tributes Mark Mobach and his research group for the impact that they have on the crossroads of various domains from public transport to mental health. Mobach: "We see the prize as enormous encouragement to continue our research into space and organisation in healthcare, education, offices, and cities together with our partners. We extend our research to areas where there are perhaps fewer financial possibilities, such as research with the arts and frailty."

Research focus area

With his research group, Prof. Mobach wants to contribute to the best buildings for people and organisations. He does so by devising better space and services in a multidisciplinary setting together with students, lecturer-researchers, Ph.D.-students, and postdocs. Better spaces and services for education, offices, and even cities that stimulate healthy behaviour, better healthcare buildings that reduce stress, but also prisons and stations that better meet the needs of society.