

Spring 2023

Syllabus

ARCH-7362 Healthy Buildings: Science and Application

Updated on 1/4/2023

Location: Meyerson Hall B7

March 16, 2023 - April 27, 2023

Thursdays, 5:15pm - 8:15pm

Instructor: Jie (Jay) Zhao, PhD

izhaonyc@upenn.edu

Healthy Buildings: Science and Application is a six-week graduate level course that examines the scientific evidence of how different elements of the indoor environment impact human health and well-being, and discusses practical design and technology applications for offices, homes, schools and other spaces.

We spend 90% of our time indoors. Understanding the interaction between the built environment and human health has never been more important. The notion that your indoor environment can make you happier, healthier and more productive is well accepted. There is increasing demand for the knowledge and experience in healthy buildings from architectural design firms, corporate workplace strategies, real estate management and investment, as well as technology companies. Corporations and consumers are willing to pay more to improve the spaces where they work, live and play.

The interdisciplinary scientific evidence of how different elements of the indoor environment can impact our health and well-being is abundant and growing. Years of public health studies have shown that air quality, water quality and material safety have profound and quantifiable impacts to our physical and mental health, and directly contribute to the global burden of diseases. Emerging studies in the fields of neuroscience and psychology have shown convincing evidence that light and biophilic design elements can impact people's mental health. Building scientists have extensively studied the impact of thermal, acoustic and ergonomic comfort in different spaces for different people. Recently, the behavioral economics concepts of nudges and persuasive technologies have also been adopted by the building industry to encourage occupants to adopt healthier lifestyles. This course will examine all the scientific evidence mentioned above.

As an architecture student, you need to first understand art and science, and then balance form and function. This course focuses on explaining the science and inspires you to design for function. Of course, art and form would always be embedded in every step of the design project.

The goals of the course are to:

1. Understand the state-of-the-art science of healthy buildings and how built environments impact people;
2. Discuss and evaluate design and technology solutions in different aspects of the built environments;
3. Apply design and technology solutions to a practical design project.

This course has three components to support students achieving the learning objectives outlined above. The lectures in each class mainly focus on providing the theoretical framework of the science of healthy buildings. The instructor-led class exercises, presentation, and discussions mainly focus on evaluating and researching on design and technology solutions following the topics of the lectures. The outcome of the class exercises will become the foundation for the course assignment.

There are no prerequisites for this course. However, students with knowledge and experience in architecture, architectural engineering and other related fields would benefit more from this course. At the end of the course, students are expected to understand the science behind healthy buildings and can incorporate these knowledge and mindset in their design projects.

Course Schedule

Date	Week #	Topics of the lectures	Assignments
March 16	Week 1	Why Healthy Buildings? Public health and cost benefit	Reading and project assignment #1 - the goal of the project
March 23	Week 2	Environmental Factors Part 1: Indoor air quality and thermal comfort	Reading and project assignment #2 - air and thermal design
March 30	Week 3	Environmental Factors Part 2: Water quality, materials and sound	Reading and project assignment #3 - water quality, materials and acoustic design
Optional - dependent on the class schedule		Class trip to NYC to visit WELL certified buildings	

April 6	Week 4	Environmental Factors Part 3: Light, biophilia, and other mental health design considerations	Reading and project assignment #4 - mental health design
April 13	Week 5	Behavioral Factors: Movement, community, and nourishment	Reading and project assignment #5 - occupant behavior considerations in design
April 20	Week 6	Human building interaction (HBI) and other emerging topics	Final design project presentation
April 27	Week 7	Final design project presentation	-

The three hour class time would typically be separated into six parts:

- Discussion of the previous reading assignment: 10 minutes
- Lecture of the topics: 50 minutes
- Break: 15 minutes
- Project presentation and discussion: 60 minutes
- In-class project exercise: 40 minutes
- Wrap up and issue reading assignment: 5 minutes

Grading criteria

The performance evaluation of this course is based on reading assignments (20%), in-class exercises and presentations (30%), and the final course project deliverable and presentation (50%).

Students are expected to complete reading assignments as indicated on this syllabus and course lectures, and to participate in the discussion about the reading assignment from the previous week. This accounts for 20% of the final grade.

During week 1, students would learn the high-level concepts of healthy buildings and examine case studies for different space types. During the in-class project exercise, students are required to form a team of no more than two people and choose one topic as their project.

From week 2 to week 6, students would have the opportunity to come up with a design strategy during each class for their design project. After class, each team is required to complete the design of their projects based on the strategies identified in class. For example, in week 2, the lecture topics include indoor air quality and thermal comfort so students would spend around 40 minutes during class time to work with the instructor to come up with design strategies to improve indoor air quality and thermal comfort for their projects. After class, each team would implement their design strategies and complete the design for their project. In week 3, each team would present their design on air quality and thermal

comfort for their design project. The quality and quantity of the discussions, presentations, and in-class exercises about each team's project would be evaluated and counted towards 30% of the final grade.

The week 7 class would be the final presentation for everyone to submit their final documentation and present to the class of their project deliverables. This overall course project accounts for 50% of the final grade.

The 100 point grading scale for this course is in the table below. Other grading considerations are in line with the official [school grading policies](#).

100 Point Grading Scale	Letter Grade Equivalent
100-104	A+
96-100	A
90-95	A-
85-89	B+
80-84	B
76-79	B-
70-75	C+
65-69	C
60-64	C-
55-59	D
0-58	F

Course Reading Material

- Week 1:
 - Mandatory:
 1. Tarlov AR. (1999) Public policy frameworks for improving population health. Ann N Y Acad Sci. 896:281-93. <https://pubmed.ncbi.nlm.nih.gov/10681904>.
 2. World Green Building Council Report. (2014). Health, Wellbeing and Productivity in Offices. Accessed on December 23, 2021. https://www.glass.org/sites/default/files/2020-09/worldgbc_health_wellbeing_productivity_short_report.pdf
 - Optional:
 1. Institute for Health Metrics and Evaluation. Global Burden of Disease (GBD). Accessed on December 27, 2022.

<https://www.healthdata.org/gbd/2019#:~:text=The%20Global%20Burden%20of%20Disease,be%20improved%20and%20disparities%20eliminated.>

2. GBD 2019 Risk Factors Collaborators. (2020) Global burden of 87 risk factors in 204 countries and territories, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. *The Lancet*. 396: 1223 - 1249.
[https://doi.org/10.1016/S0140-6736\(20\)30752-2](https://doi.org/10.1016/S0140-6736(20)30752-2).
3. Klepeis NE, Nelson WC, Ott WR, et al. (2001) The National Human Activity Pattern Survey (NHAPS): a resource for assessing exposure to environmental pollutants. *Journal of exposure analysis and environmental epidemiology*. 11(3):231-252. <https://www.nature.com/articles/7500165>.
4. EY. (2021) The future of sustainability reporting standards: the policy evolution and the actions companies can take today. Accessed on December 23, 2021.
https://assets.ey.com/content/dam/ey-sites/ey-com/en_gl/topics/sustainability/ey-the-future-of-sustainability-reporting-standards-june-2021.pdf
5. Loftness, V., Hartkopf V., Grtekin B. et al. Building Investment Decision Support: Cost-benefit tool to promote high performance components, flexible infrastructures and systems integration for sustainable commercial buildings and productive organizations. Carnegie Mellon University. Accessed on December 23, 2021. https://www.brikbases.org/sites/default/files/aia080586_01.pdf
6. Lister, K. (2014). What's Good for People, Moving from Wellness to Well-Being. Knoll Workplace Research. Accessed on December 23, 2021.
https://www.knoll.com/document/1353003180652/Well_Being_wp.pdf
7. International WELL Building Institute. (2021). WELL v2 country briefs. Accessed on December 23, 2021.
<https://www.wellcertified.com/certification/v2-pilot/country-briefs>
8. International WELL Building Institute. (2021). WELL Building Standard v2. Accessed on December 23, 2021.
<https://v2.wellcertified.com/wellv2/en/overview>

- Week 2:

- Mandatory:

1. Wang Z, de Dear R, Luo M, Lin B, He Y, Ghahramani A, Zhu Y, (2018) Individual difference in thermal comfort: A literature review, *Building and Environment*, <https://www.sciencedirect.com/science/article/abs/pii/S0360132318302518>
2. International WELL Building Institute. (2021). WELL Building Standard v2. Accessed on December 23, 2021.
<https://v2.wellcertified.com/wellv2/en/overview> (only on Air, Water, Thermal, Material)

- Optional:

1. Landrigan PJ. Air pollution and health. *The Lancet Public Health*. 2017;2(1).
[doi:10.1016/S2468-2667\(16\)30023-8](https://doi.org/10.1016/S2468-2667(16)30023-8)
2. Burkart, K.G., Brauer, M., Aravkin, A.Y., et al. (2021) Estimating the cause-specific relative risks of non-optimal temperature on daily mortality: a two-part

modelling approach applied to the Global Burden of Disease Study. Lancet 2021; 398: 685–97.

<https://www.thelancet.com/action/showPdf?pii=S0140-6736%2821%2901700-1>

- Week 3:

- Mandatory:

1. International WELL Building Institute. (2021). WELL Building Standard v2. Accessed on December 23, 2021.
<https://v2.wellcertified.com/wellv2/en/overview> (only read Water, Sound, and Materials)
2. Understanding at least one of the six material safety programs: [Healthy Product Declaration Program](#), [Declare](#), [UL GREENGUARD](#), [Cradle to Cradle](#), and [Level by BIFMA](#).
3. Bernstein, E.S. and Turban, S. (2018). The impact of the ‘open’ workspace on human collaboration. Phil. Trans. R. Soc. B3732017023920170239.
<https://doi.org/10.1098/rstb.2017.0239>.

- Optional:

1. Clasen T, Pruss-Ustun A, Mathers CD, Cumming O, Cairncross S, Colford JM Jr. Estimating the impact of unsafe water, sanitation and hygiene on the global burden of disease: evolving and alternative methods. Trop Med Int Health. 2014 Aug;19(8):884-93. <https://onlinelibrary.wiley.com/doi/full/10.1111/tmi.12330>.
2. Health effects caused by noise: Evidence in the literature from the past 25 years. Ising, H and Kruppa, B. 22, Berlin : s.n., 2004, Noise & Health, Vol. 6, pp. 5-13.
<http://www.noiseandhealth.org/article.asp?issn=1463-1741;year=2004;volume=6;issue=22;spage=5;epage=13;aulast=Ising>.
3. S. P. Banbury and D. C. Berry, “Office noise and employee concentration: identifying causes of disruption and potential improvements,” Ergonomics, vol. 48, no. 1, pp. 25–37, Jan. 2005,
<https://doi.org/10.1080/00140130412331311390>.

- Week 4:

- Mandatory:

1. International WELL Building Institute. (2021). WELL Building Standard v2. Accessed on December 23, 2021.
<https://v2.wellcertified.com/wellv2/en/overview> (only read Light and Mind)
2. Putrino, D., Ripp, J., Herrera, J.E., et al. (2020) Multisensory, Nature-Inspired Recharge Rooms Yield Short-Term Reductions in Perceived Stress Among Frontline Healthcare Workers. Frontiers in Psychology, 11, 2020: 3213.
<https://www.frontiersin.org/article/10.3389/fpsyg.2020.560833>.

- Optional:

1. Berto, R. (2005) Exposure to restorative environments helps restore attentional capacity. J. Environ. Psychol., 25(3), 249–259.
<https://doi.org/10.1016/j.jenvp.2005.07.001>.

2. Brown, D. K., Barton, J. L., and Gladwell, V. F. (2013) Viewing Nature Scenes Positively Affects Recovery of Autonomic Function Following Acute-Mental Stress. *Environ. Sci. Technol.* 47(11) 2013: 5562–5569.
<https://doi.org/10.1021/es305019p>.
 3. Jamrozik, A., Clements, N., Hasan, S.S. et al. (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, 2019: 106379, <https://doi.org/10.1016/j.buildenv.2019.106379>.
 4. Cameron A., Burns, P., Garner, et al. (2019) Making Sense of Multi-Sensory Environments: A Scoping Review, *International Journal of Disability, Development and Education*, <https://doi.org/10.1080/1034912X.2019.1634247>.
- Week 5:
 - Mandatory:
 1. International WELL Building Institute. (2021). WELL Building Standard v2. Accessed on December 23, 2021.
<https://v2.wellcertified.com/wellv2/en/overview> (only read Nourishment, Movement and Community).
 2. City of North Vancouver. (2015) Active Design Guidelines.
<https://www.cnv.org/-/media/City-of-North-Vancouver/Documents/Active-Design/Active-Design-Guidelines.pdf>.
 3. Nancy D. Berkman, Terry C. Davis & Lauren McCormack (2010) Health Literacy: What Is It?, *Journal of Health Communication*, 15:sup2, 9-19,
<https://doi.org/10.1080/10810730.2010.499985>.
 - Optional:
 1. Daniel Kahneman (2011). *Thinking, Fast and Slow*. Macmillan.
 2. Thaler, Richard, and Cass Sunstein (2008). *Nudge: Improving Decisions About Health, Wealth, and Happiness*. Penguin Books.
 3. Michael Lewis (2016). *The Undoing Project*. W. W. Norton & Company.
 4. Gladwell, Malcolm (2007). *Blink*. Back Bay Books.
 - Week 6:
 - Refer to the course slides.