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Teaching HCI Foundations and Frontiers



Michael Bernstein · [Follow](#)

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How do we ground students not just in the practice of human-computer interaction, but also in the theories and big ideas that animate the field? When there's a vast library of theories, visions, architectures, and critiques, not every design idea has to start from the drawing board. I've recently redeveloped our advanced HCI course for undergraduates and graduate students to weave our major HCI theories into modern topics.

Required HCI curricula tend to focus on the design process, leaving a gap in teaching HCI's big theories.

Design is important, but when the one required class in HCI is a design process course, our graduates leave with immense gaps. It's a mistake for us to graduate students who can competently execute the human-centered design process but don't have the tools to adapt it, refashion it, or question why it works the way it does.

When we at Stanford HCI laid out our learning goals for HCI track majors in Computer Science, we realized that there was an enormous gap on the theory side. We all felt that it was a mistake to send our students out into the world without an understanding of the major ideas that shape modern HCI. I'm going to use the term *theories* here to capture the wide variety of conceptual apparatus we draw on in HCI: while some may go by the term "theory", others are described as visions, ideas, critiques, systems, models, or principles. Here's a slice of them:

Ubiquitous computing	Beyond being there	Programming as problem representation
Tangible computing	Grudin's paradox	Design principles for visual communication
Ubicomp sensing pipeline	Distance matters	Encodings, marks, and visual variables
Commodity vs. infrastructure-mediated sensing	Socio-technical gap	Graphical perception of information
Design fixation	Crowdsourcing / coordination at scale	Cognitive models
Demand characteristics	The Johansen Matrix	Embodied cognition
Gulfs of execution and evaluation	Feminist HCI	HCI methodological plurality
Analogical transfer	AI vs. IA	Ability-based design
Wicked problems	Direction Manipulation vs. Agents	ICT4D
Participatory design	Mixed Initiative Interaction	
Design patterns	End-user programming	
Reflective practitioner	Threshold and ceiling	

A subset of the major theories in HCI that we wanted to make sure our students understood.

When I would ask students to dive in and read these original works in prior classes, undergraduates would connect with the details rather than the deeper ideas: “Well, *I’d* never make that mistake” or “Well, *I’d* never use that design”. And to a certain extent, that’s fair: many of our big ideas are phrased in the technologies of their time. I estimate the half life of a useful real-world example in HCI to be about five years (“ugh, I was *a sophomore in high school* when that came out!”). Clippy is prehistory, and Facebook is greeted with eye rolls. But the reason these theories are important is that they continue to animate our work today—for example, in tech and society, in ubiquitous computing, or even in why the design process operates the way that it does.

So, craft a course that teaches the big ideas in HCI through the ways that they live on in today’s problems.

The basic recipe that I’ve found works is one that I’ll call “Foundations and Frontiers”. The basic concept is, for each lecture, teach one of the big theories in HCI (a foundation) and use it to explore, explain, and question modern problems facing computing and society or HCI today (frontiers).

For example, our first lecture introduces Mark Weiser’s concept of ubiquitous computing—a vision that serves as a very concrete jumping off point. Weiser’s vision proposes a very specific theory: that computing technology ought to become as invisible as infrastructure. This is easy enough to describe. But, when students

read Weiser's Scientific American article, it can feel a bit retro-futurist. How do we get students to really wrestle with Weiser's concepts of calm computing, of tabs/pads/boards, of influential theoretical complements of that vision such as tangible computing, and of critical responses to the vision?

It turns out that modern research frontiers are a fantastic way to ground these questions. They are fresh and engaging, since they're typically more recent publications that haven't hit mainstream industry or widespread intellectual acceptance yet. And I don't have to invent them, since HCI colleagues already have. Here's a smattering of some of the projects I use to explain ubiquitous computing to advanced undergraduates and graduate students:

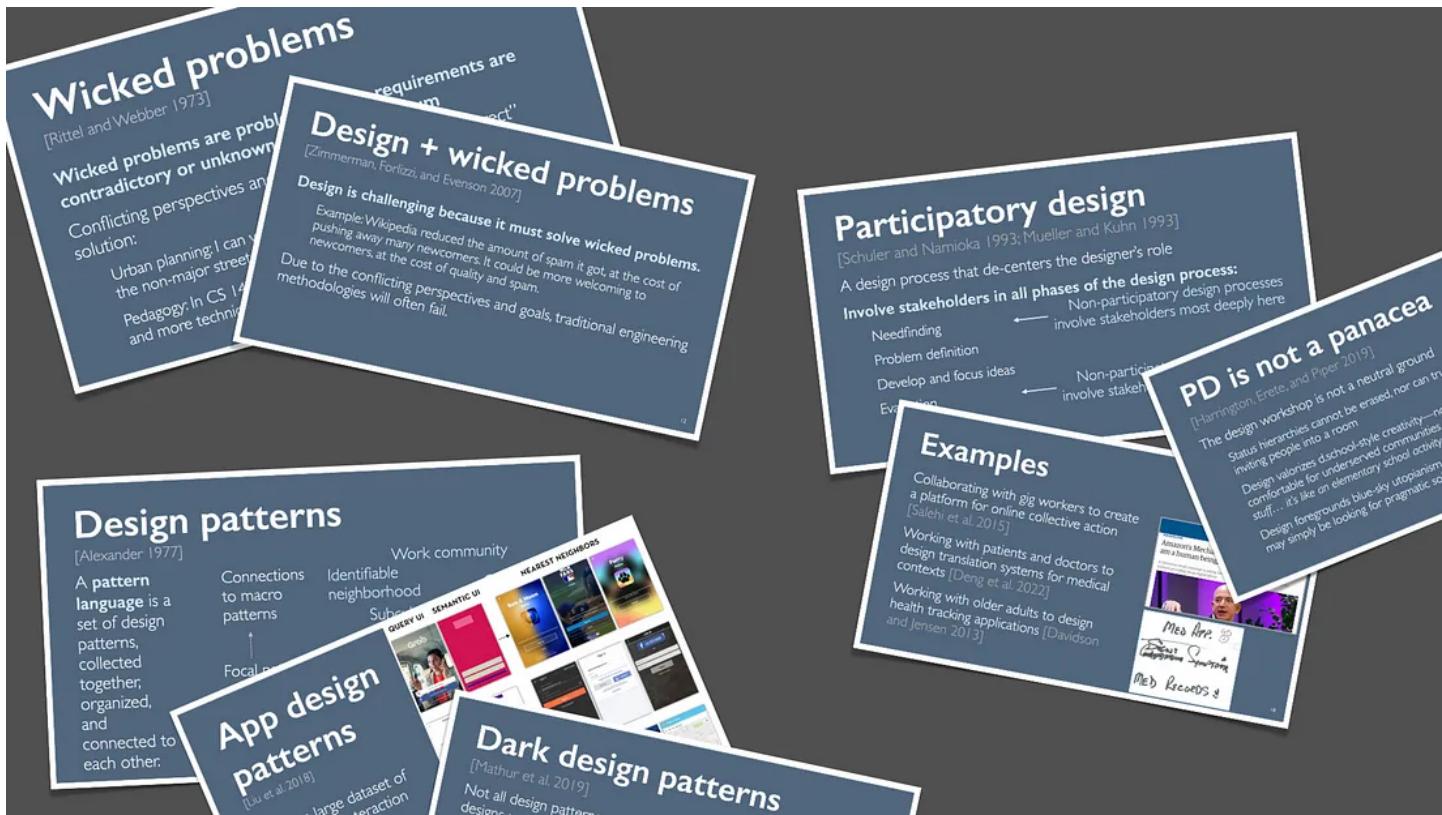


In other words, I teach a theory class using research as my figures and illustrations.

The whole syllabus from last year is here: <http://cs347.stanford.edu>. I'm happy to share slides, just ping me at msb@cs.stanford.edu. Here some other examples of how to I taught a lecture course big ideas from HCI using research frontiers to illustrate core concepts.

Design process: teaches wicked problems, participatory design, and design patterns, using recent examples on challenges in power and status in PD, designing as a wicked problem, mining design patterns, and dark design patterns. To do this,

we anchor in recent work mining design patterns from apps, in catalogues of dark design patterns, and the status and accessibility issues with PD.



Social media: teaches foundational concepts of Beyond Being There, Grudin's Paradox, and social media's impact on people and society. The frontiers I use to illustrate these concepts include ads of VR/Slack being “as good as being there”, research projects such as SquadBox as examples of going beyond being there, recasting Grudin’s Paradox as an explanation for social media cold start failures, and recent work on the impact of social media on wellbeing and democracy.

"It's like being there!"

A major design goal of social computing has been increase fidelity of online social interaction. [Difesa et al. 2018]

- "Let's make ZOOM resolution."
- "Let's make where it's your friend."

Beyond being there

Hollan and Stornetta, 1993

"Being there" is the wrong goal.

We will never fully recreate the face-to-face experience. There are too many subtle cues for us to fully model or recreate them, even with hypothetical future technology.

Network lag, immersion and comfort issues, lack of context, ...

So, stop trying.

Collaborate online as easily as you do in person

How to Have a Zoom Meeting That Is (Almost) as Good as Being There

→ like you're there: Swedish reality business once in Portsmouth.

The Vision

YOU READ THIS

Good Stuff: Users, Happiness

Time

The Reality

Your friend, who you guided into using the platform once

Time

Grudin's Paradox, or Why Online Communities Fail And What To Do About It

Why do social media fail?

[Grudin 1994]

Many platforms—social media, documentation wikis at work, usage of messaging software—never get over the adoption hump. Why? Grudin offers several trenchant answers. Two that stuck:

- Disparity between who puts in the work and who benefits**
- Documentation: manager benefits, employee contribute**

Failure to reach critical mass: "cold start"

Tragedy of the commons: it's rarely in a single user's best interest to use a new social computing system

Ask a question! It's routed to the right person, anywhere

Friendsourced moderation

Combat censorship

Facebook Knows Instagram Is Toxic for Teen Girls, Company Documents Show

TikTok self-harm study results: every parent's nightmare

A Former Facebook VP Says Social Media Is Destroying Society. And He's Right.

How does social media impact... Democracy?

"Some associations, such as increasing political participation and information consumption, are likely to be beneficial for democracy and were often observed in autocracies and emerging democracies. Other

How does social media impact... Our well-being?

"Receiving targeted, composed communication from strong ties

AI+HCI: teaches mixed-initiative interaction, IA vs. AI, mental models vs. folk theories, trust in algorithms, and algorithmic audits. This one is easy to anchor in recent advances.

"Don't let your UI write a check that your AI can't cash."

- Eytan Adar [2018]

AUGMENTING HUMAN INTELLIGENCE: A CONCEPTUAL FRAMEWORK

Prepared for:
DIRECTOR OF INFORMATION SCIENCES
AIR FORCE OFFICE OF SCIENTIFIC RESEARCH
WASHINGTON D.C.
By: D. C. Eggler

CONTRACT AF 49(038)-1004

STANFORD RESEARCH INSTITUTE
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Mixed-initiative, intuitively

You don't need to decide between full control and full automation. Instead, the system should automate the things it can, hand control to the user for the things it can't, and ask the user if it's unsure.

Today, mixed-initiative interaction typically refers to the mode of suggesting an action and letting the user confirm it

Mixed initiative: visually

$\begin{matrix} & \text{a}(\neg A, \neg G) \\ \text{Expected value} & \diagdown \quad \diagup \\ & \text{a}(A, \neg G) \\ \text{a}(A, G) & \diagup \quad \diagdown \\ & \text{a}(\neg A, G) \end{matrix}$

$P(G)$

Frontier: image editing through demonstration

"Make this part of the source image look more like the reference image." - [Ko et al. 2022]

Why AI is difficult to design

[Yang et al. 2020]

How do we know what AI can and cannot do, and how it will err? How do we engage in rapid prototyping of AI-powered systems? How do we control the unpredictable output of the AI? Michael would add: We are risk averse and will avoid AI-powered interactions once we stumble into one of their limits: algorithm aversion. If "Alexa, play a reggae song by Beyond" returns the wrong text message, dictation errs you back off to the

Software agents

We should delegate to proactive artificial intelligence systems

Direct manipulation

Users should always have full control, even as automation increases

Agents

AI agents ask questions about images on social media to learn about the world around them [Zecchina et al. 2022]

Learn to automate tasks that you do commonly [Mills 1995]

Audit examples

Google ads for Black names are 25% more likely to suggest arrest records [Sweeney 2013]

Algorithmic risk scores for a bail-setting algorithm were higher for Black defendants than (otherwise equivalent) White defendants [Angwin et al. 2016]

Algorithmic health risk scores will assign the same level of risk to a sicker Black patient than a White patient [Obermeyer et al. 2019]

Why? Often because the algorithm conflates signals. E.g., health cost is a proxy for health needs—but less money is spent on Black patients

Our trust isn't calibrated

Algorithm aversion—we prefer human decision-making to AI even if the algorithm is better at the task [Dietvorst, Simola, Masse 2015]

...and especially after seeing the algorithm make an error

What if the algorithm just suggests the answer to you? [Angwin, Larson, Patil, and Gaskell 2016]

We often get influenced by the AI's suggestion and rely on the algorithm to explain its reasoning

Industry teams struggle to address these challenges

Ideally, we engage with stakeholders early [Zhu et al. 2018]

But, in practice in industry... [Hofsten et al. 2019]

Data collection is a problem ("almost no effective audit turns up a problem")

Checking

Assignments prompt students to engage with the primary sources, apply theories, and extend theories.

The course is primarily lecture and discussion-based. However, I keep some important assignment structures that I inherited from Scott Klemmer and Jeff Heer when I got to Stanford a decade ago. Specifically, for each lecture, I have students read one to two papers, and submit some reflections to queue up for their small group discussion. Students meet in their discussion groups once a week to dig into their opinions on the lecture and readings. Once per quarter, they act as a discussant, summarizing the opinions of their discussionmates and working with the TA to drive that today's discussion.

Yes, I have quizzes. It's because many of the ideas in the course come out only in lecture, and I wanted to promote revisiting and remembering that material. I try to keep them small and lightweight.

As we proceed through the quarter, students begin a final course project in teams. The goal of the project is to push on the frontiers of HCI. I don't call it a research project, though students can pursue novel contributions if they want. Instead, I ask them to grab hold of one of the ideas introduced in the class, and push it through a technical artifact, behavioral study, or theoretical reflection.

More at <https://cs347.stanford.edu>.

What works, and what doesn't (yet)

When I revamped the course this past winter, it was an absolute blast to teach. I basically got to take everything that students had learned so far in HCI, keep asking "but why does it work that way?", and then work with students to reconstruct their understanding of why we do what we do, where the field is going, and how to wrestle with tough societal and ethical consequences of what we create.

What seems to be working most effectively is getting students to "pop up a level", and question themselves and their ideas rather than blindly applying the user-centered design process. As one student put it in their course evaluation (yes, I read them), one student mentioned, "I learned the strings that pull and unify HCI together," and another, "I gained a better grasp of HCI's grounding theories, historical arc, and major themes." Classes don't have to be easy, but they do need to be worth the effort, as one student mentioned: "The readings might be challenging

sometimes but it really gives you a chance to rethink the way that you currently perceive HCI.”

In terms of what's not yet totally resonating, it was hard to push students away from an assumption that they needed to do a research project for their course project. I wasn't against that, but the project didn't really require it. In the future, I'm going to provide much stronger scaffolding on what constitutes a viable course project. I also don't feel like I've completely cracked the quiz genre yet for this course—I often tried to provide an example design concept and ask students essentially whether it was a good or bad idea based on theories presented in the course. Here, some students would get extremely creative about which theories apply, and it challenged the TAs in grading fairly.

At my most ambitious, I want to see HCI's big ideas centralized and presented crisply in every HCI curriculum, rather than overlooked or spread out across a number of electives. At my least ambitious, I'm going to keep pulling this thread.

Hci



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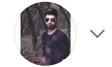
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$$\pi \approx \frac{\sqrt{2^1 + 2 \cdot 3}}{(1 - 2) + 3} \cdot \frac{3.14}{5^2} \cdot \frac{5(2 + 2)}{1 \cap 1}$$

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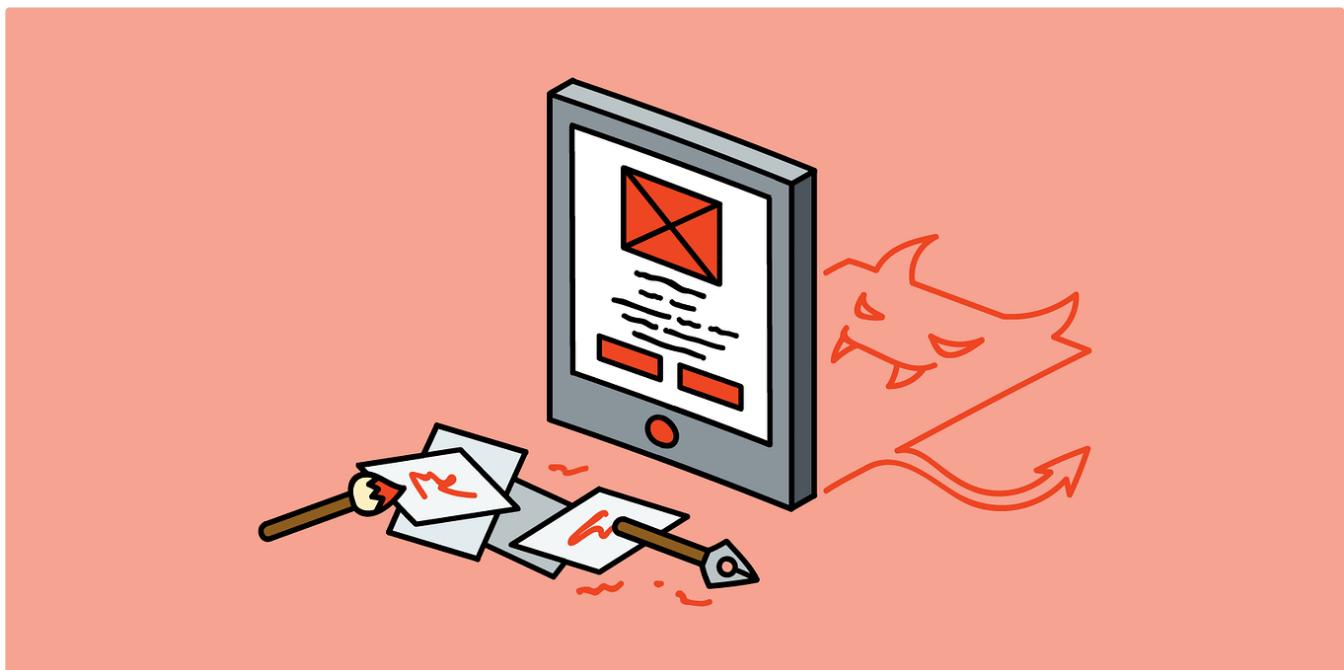
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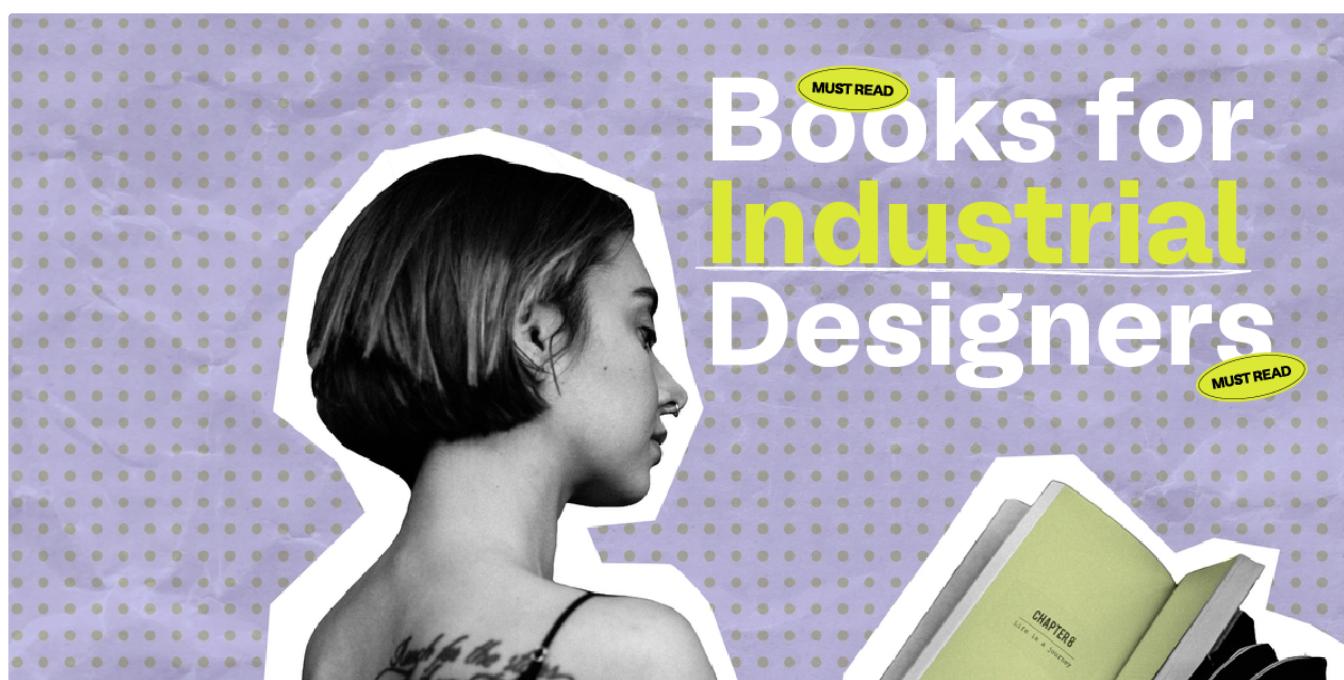
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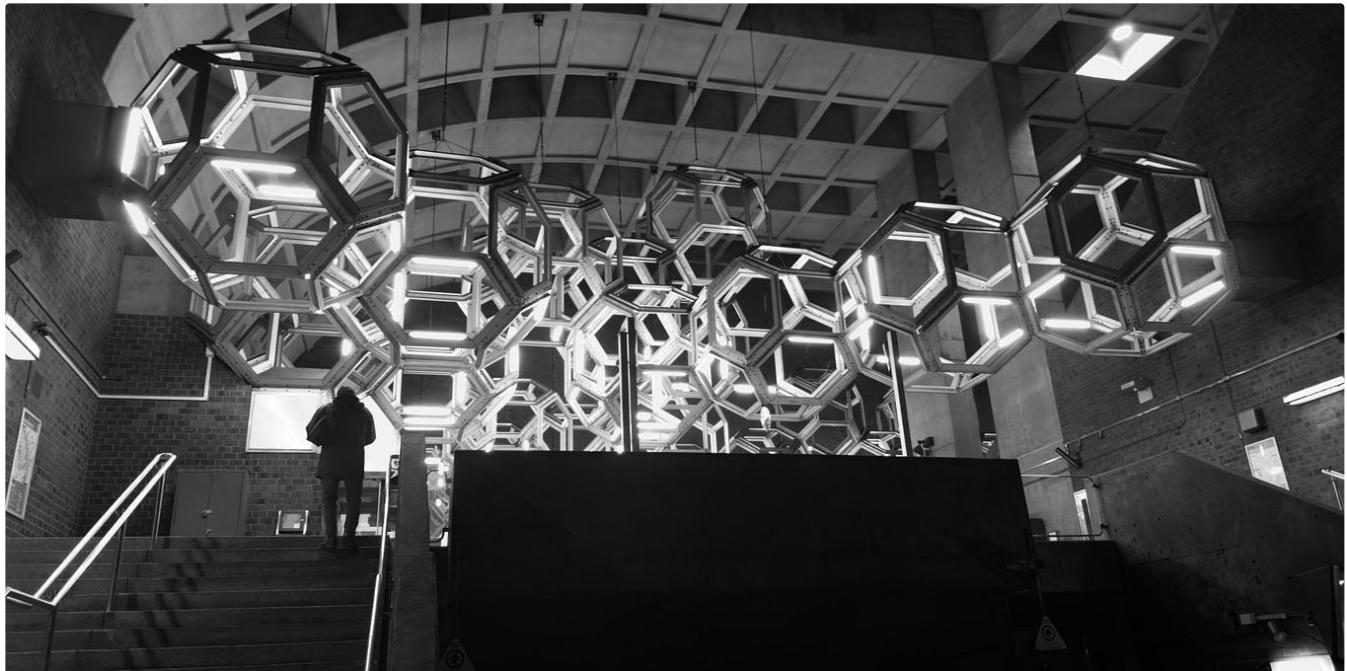
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