Transdisciplinary

TE ENGINEERING

Keynote Title

Good Designers do "X"

Wednesday, July 12, 2023

13:00-14:00

www.te2023.ait.ac.th

Good Designers do “X”

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Pronouns: she/her

Transdisciplinary Engineering Conference, July 12, 2023
“Leveraging Transdisciplinary Engineering in a Changing and Connected World”

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CELT
CENTER FOR ENGINEERING LEARNING & TEACHING

TE22: “Transdisciplinarity and the Future of Engineering”

TE 2022 conference paper titles without "transdisciplinary" and "engineering"

Engineering is…

…design under constraint.

(William Wulf, U.S. National Academy of Engineering President,1998)

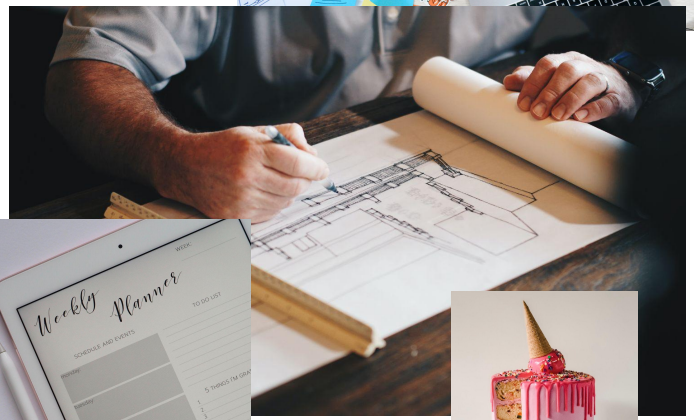
Engineering is design under constraint

- Constrained by
  - Nature
  - Safety concerns
  - Environmental concerns
  - Cost
  - Reliability
  - Constructability
  - Maintainability
  - Many other such “ilities”
- Engineering is…
  - Creative
  - Designing what can be; seeing possibilities

(William Wulf, NAE President,1998 - https://www.nae.edu/7580/TheUrgencyofEngineeringEducationReform

Design can be a challenge to teach

- Many definitions of design
  - Noun, verb, adjective
  - What we call a final product, or a sketch of an idea…
  - Engaging in an act of creation
- An important component of engineering….
  - …of architecture, writing, composing, cooking…
  - …of being human
- The name of a profession
- Recent emphasis on design thinking
- Confusing to figure out what/how to teach



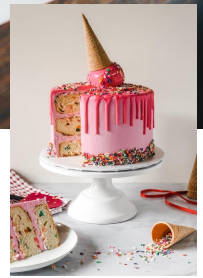
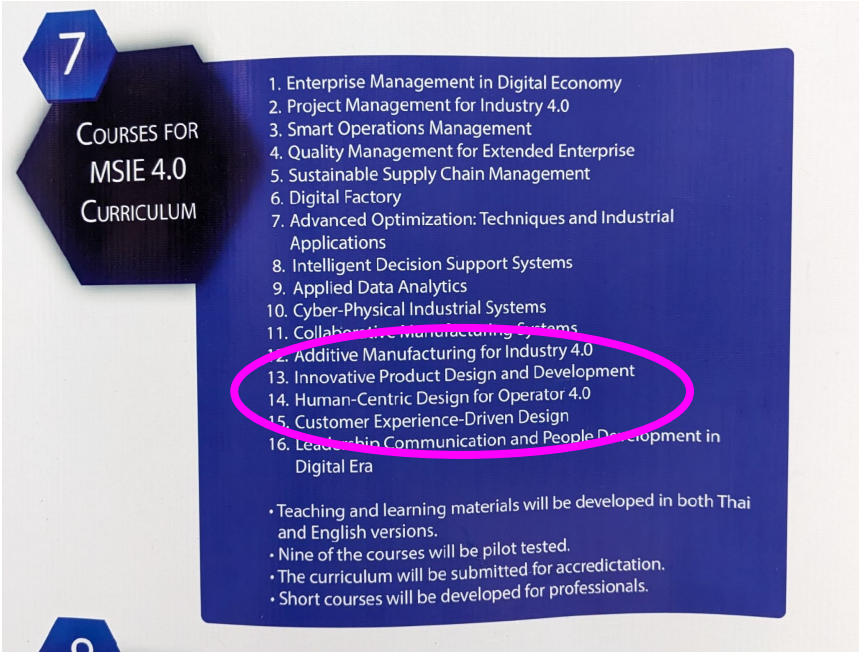


Photo by Jess Bailey, UX Indonesia, Daniel McCullough, Katie Rosario on Unsplash

MSIE 4.0 Curriculum



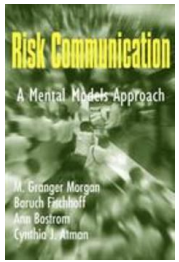
Good Designers do “X”: Today’s goal

- Engage with
  - Results from design expertise research
  - A list from researchers of what “good designers” do

- Come away with one or two things that connect to your work

Setting the stage: A focus on design teaching

- My life goal: Teach engineering students to
  - Think about impact of technology on the globe
  - Consider context in their engineering work
  - Minimize unintended consequences
- 1990: PhD, Engineering & Public Policy, CMU
  - Risk communication & mental models/risk analysis
  - Behavioral decision theory/decision theory
  - Expert/novice studies
  - Common theme: Interweaving “actually” do with “should” do



Setting the stage

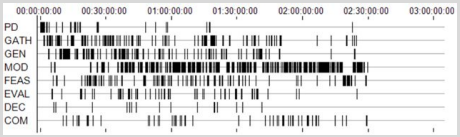
- How could engineers consider context?
  - Through doing design
- My frame:
  - Interweave “actually” do with “should” do
- My questions:
  - How do engineering students and experts engage in design?
  - Are there differences that can inform how to teach design?

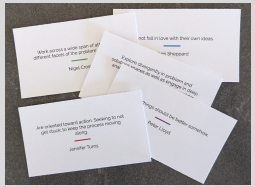
Setting the stage

- My audience was engineers
  - Quantitative data
  - Large sample sizes
- Embarked on quest, funded by National Science Foundation
  - Data from a large number of engineers doing design
    - with various levels of expertise
  - Solving design problems out loud
  - Create quantitative measures from verbal data
  - Compare processes across levels of expertise
    - E.g., experts and novices

Agenda

- Setting the stage
- Design expertise research
- Teaching design
  - Design signatures
  - Good Designers do “X”
  - Dear Design seminar
- Wrapping up





The Blank Signature, Magritte

“Magritte Moment”

A pause for curiosities and connections?

Agenda

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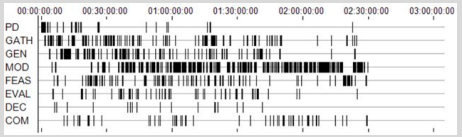


Many Collaborators

- Collaborators, co-authors, and research team members include Robin Adams, Arif Ahmer, Shiva Anem, Brad Arneson, Grace Barar, Theresa Barker, Maria Buan, Emma Bulojewski, Mary Besterfield-Sacre, Jim Blair, Carie Bodle, Laura Bogusch, Jim Borgford-Parnell, Karen Bursic, Ryan Campbell, Monica Cardella, Soomin Chang, Justin Chimka, Dharma Dailey, Kate Deibel, Yuliana Flores, Zach Goist, Brian Hayes, Melissa Jones, Khadijah Jordan, Aaron Joya, Allison Kang, Deborah Kilgore, Kristina Krause, Vipin Kumar, Alex Lew, Terri Lovins, Stefanie Lozito, Janet McDonnell, Kenya Mejia, Annegrete Mølhave, Andrew Morozov, Susan Mosborg, Carie Mullins, Heather Nachtmann, Wai Ho Ng, Will Richey, Eddie Rhone, Axel Roesler, Wendy Roldan, Jason Saleem, Giovanna Scalone, Kathryn Shroyer, Elvia Sierra-Badillo, Shaunte Smith, Roy Sunarso, Rylie Sweem, Steve Tanimoto, Jennifer Turns, Hannah Twigg-Smith, Cheryl Wang, Nicole Washington, Ken Yasuhara, Jordan Yoon-Buck, Mark Zachry, Eileen Zhang…
- …and over 75 additional undergraduate students

Examining Design Expertise: Corpus of Data

- 177 individuals solved design problems
  - 401 problems solved
  - 298 verbal protocols
- 177 individuals of various levels of expertise
  - 149 engineering students
  - 19 practicing engineering experts
  - 4 educators (IE, 2 ME, Nuclear physics)
  - 5 domain experts (playground design, landscape architecture)

Examining Design Expertise: Playground Problem

- Participants
  - First-year engineering students (n = 26)
  - Graduating senior engineering students (n = 24)
  - Practicing engineering experts (n = 19)

- Experimental Task
  - Individuals design a playground for a fictitious neighborhood
  - Subject to a set of constraints (cost, timing, number of children, etc.)

- Verbal protocol analysis
  - Individuals had up to 3 hours in a lab setting
    - Think-aloud protocol
  - Analysis
    - Transcribe audio
    - Segment text into idea units
    - Assign design process code to each idea unit

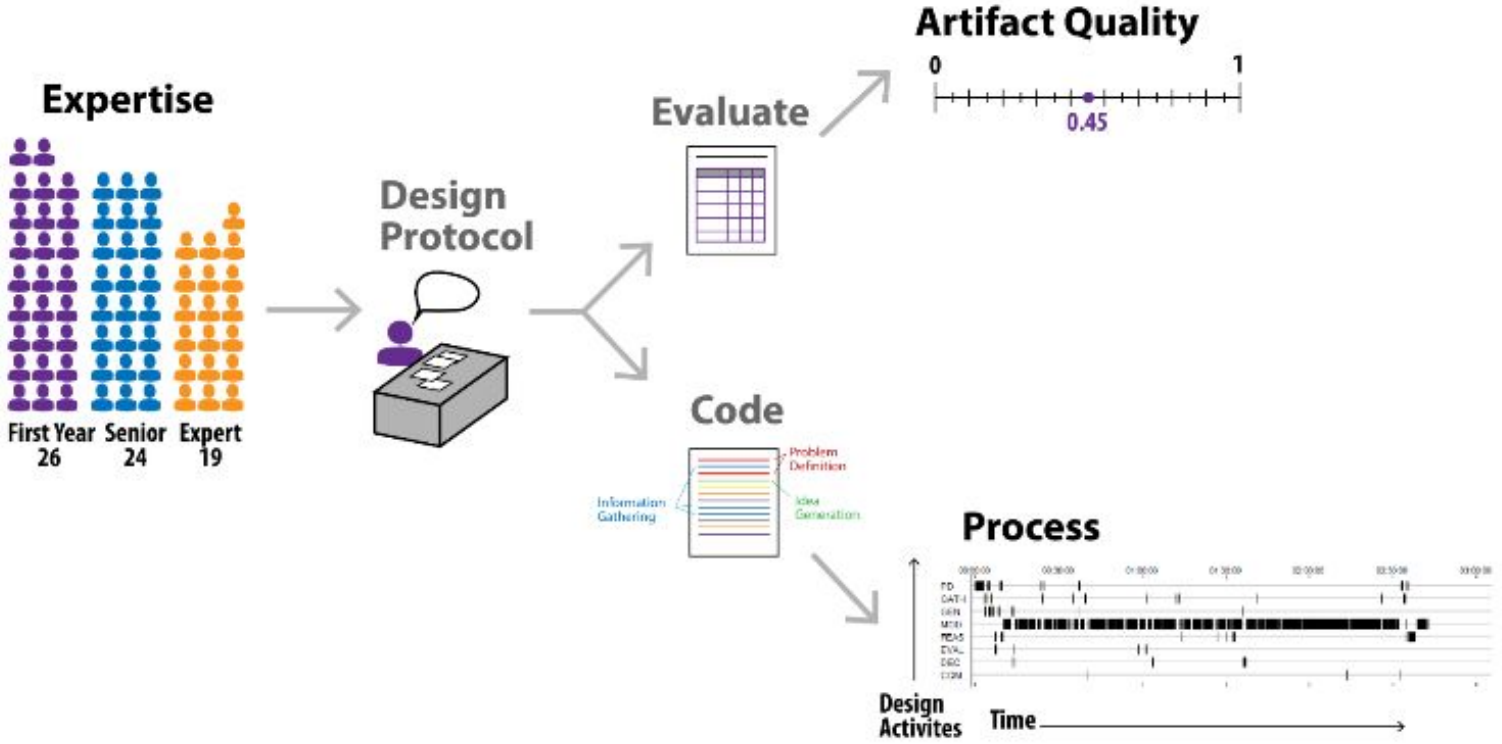
Defining Design: Design activity codes

7 Engineering Design Textbooks

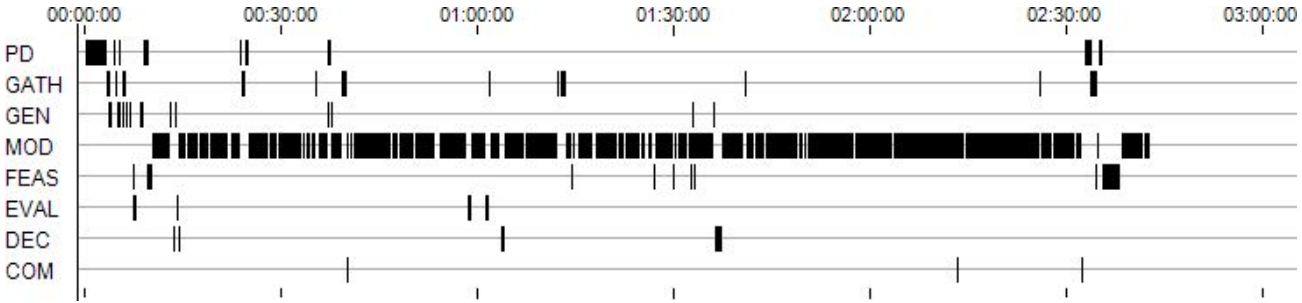
Content Analysis

(Identification of a Need)
Problem Definition
Information Gathering
Generation of Ideas
Modeling
Feasibility analysis
Evaluation
Decision
Communication
(Implementation)

Experimental setting

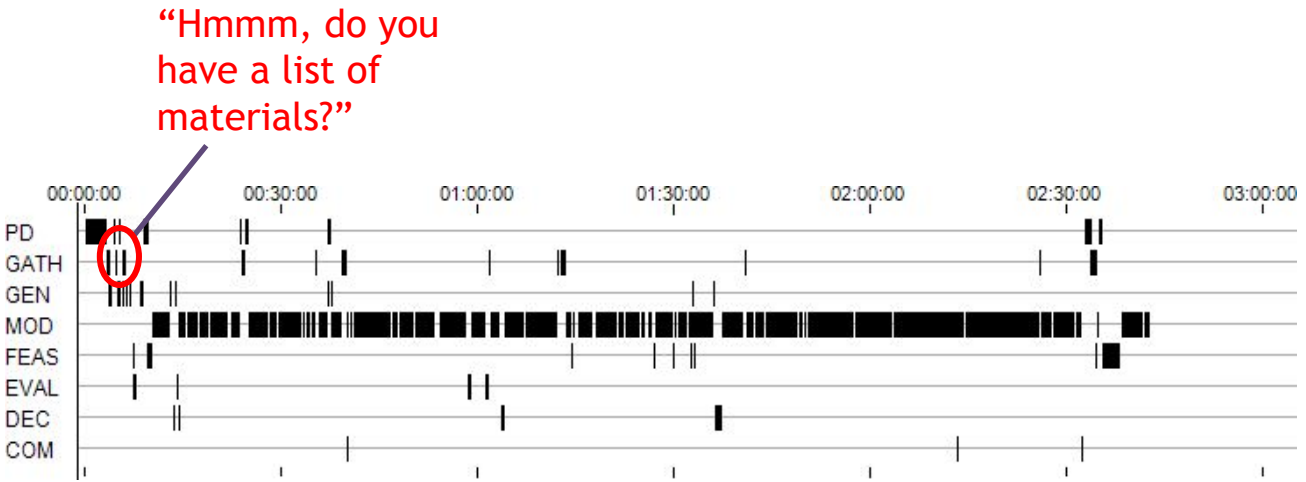


Design process timelines



PD:	Problem Definition	FEAS:	Feasibility Analysis
GATH:	Gathering Information	EVAL:	Evaluation
GEN:	Generating Ideas	DEC:	Decision Making
MOD:	Modeling	COM:	Communication

Design timeline representations



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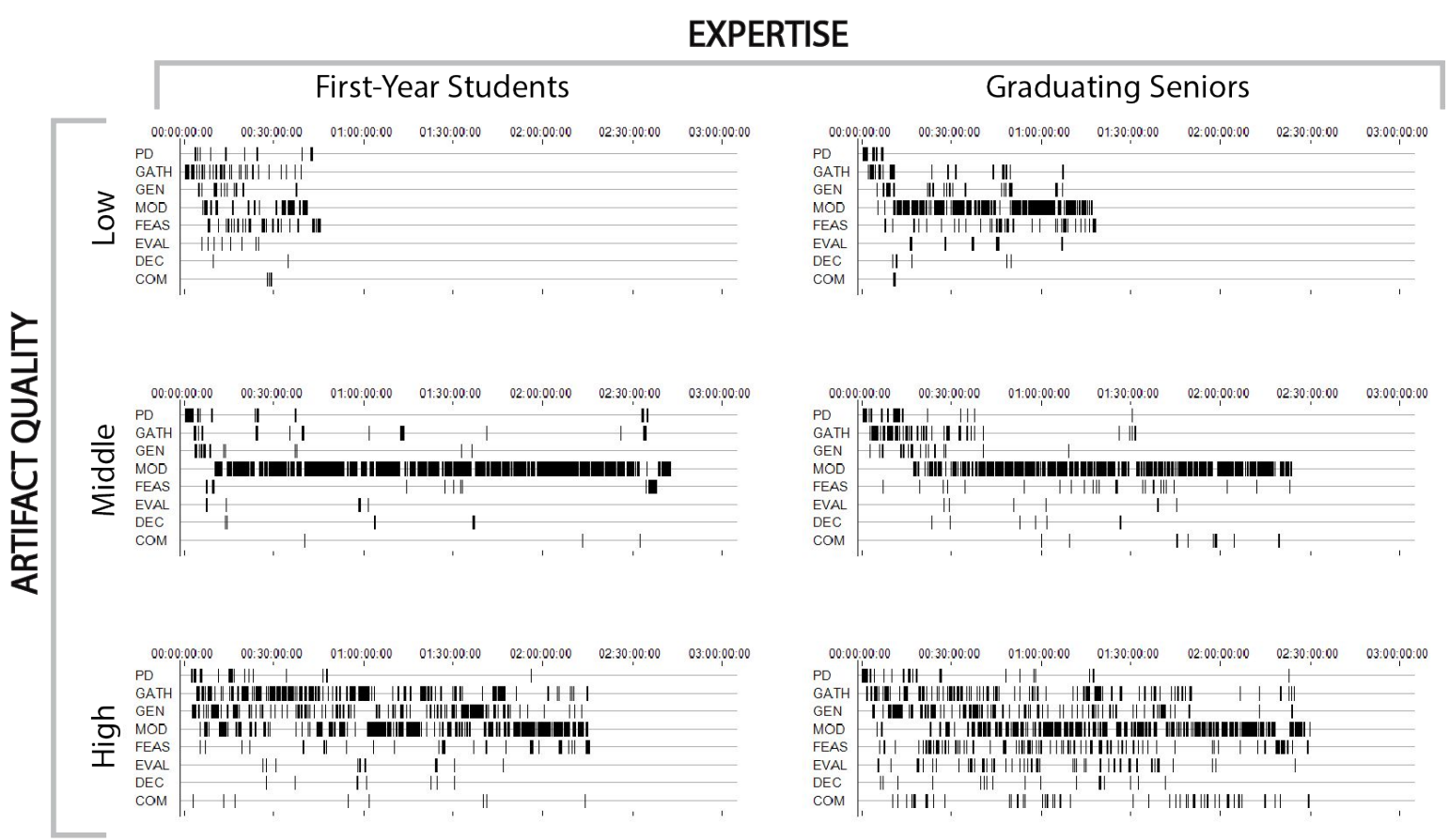


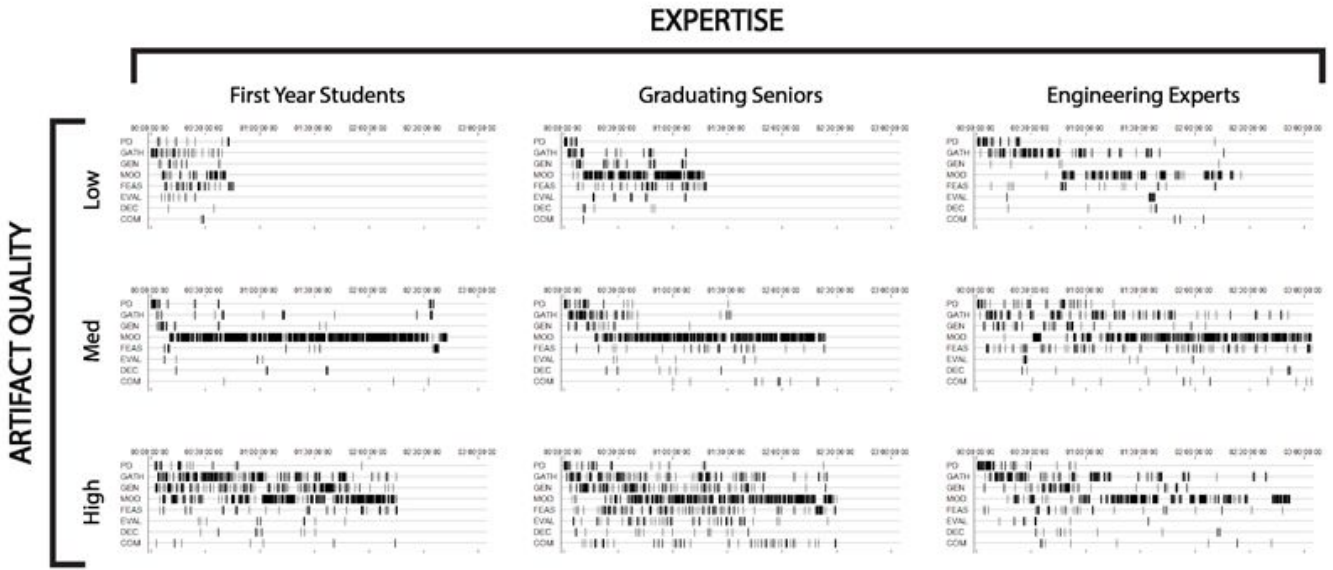
PD: Problem Definition
GATH: Gathering Information
GEN: Generating Ideas
MOD Modeling
FEAS: Feasibility Analysis
EVAL: Evaluation
DEC: Decision Making
COM: Communication

Design process research findings

- Graduating seniors were significantly more likely than first-year students to…
  - have higher-quality designs
  - make more transitions among design activities
  - scope the problem more effectively by considering more categories of information
  - progress further in the design process

(Atman, Chimka, Bursic, & Nachtmann, 1999)

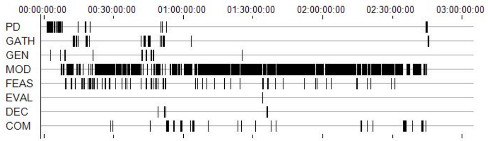
Adding in the experts

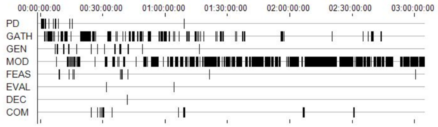


- Engineering experts were significantly more likely than students to…
  - spend more time solving the problems in all design stages
  - scope the problem more effectively by
    - gathering more information (explicitly) and
    - covering more categories
  - Spend longer problem scoping before turning to modeling
  - consider more objects in their design process
  - exhibit a “cascade” pattern of transitions

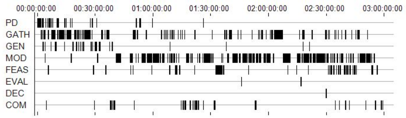
(Atman, Adams, Cardella, Turns, Mosborg, & Saleem, 2007)

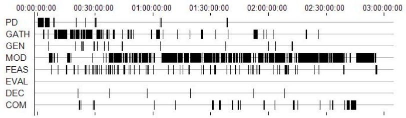
Similar patterns found:



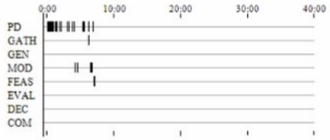


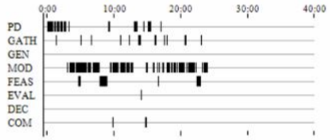
- With other design problems
- With participants from other populations
  - Students from different university
  - Engineering faculty
  - Domain experts

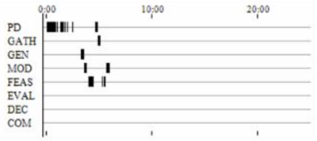


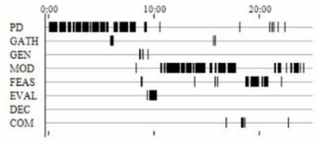


- With other experimental designs
  - Within-subject longitudinal comparisons
- With team of designers









Remembering “Identify need” and “Implementation”

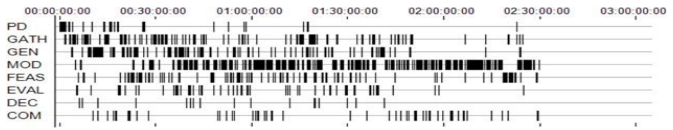
The experimental data was collected in a lab-based setting

(Identification of a need)
Problem definition
Information gathering
Generation of ideas
Modeling (prototyping)
Feasibility analysis
Evaluation
Decision
Communication
(Implementation)

In the real world designers also engage in:

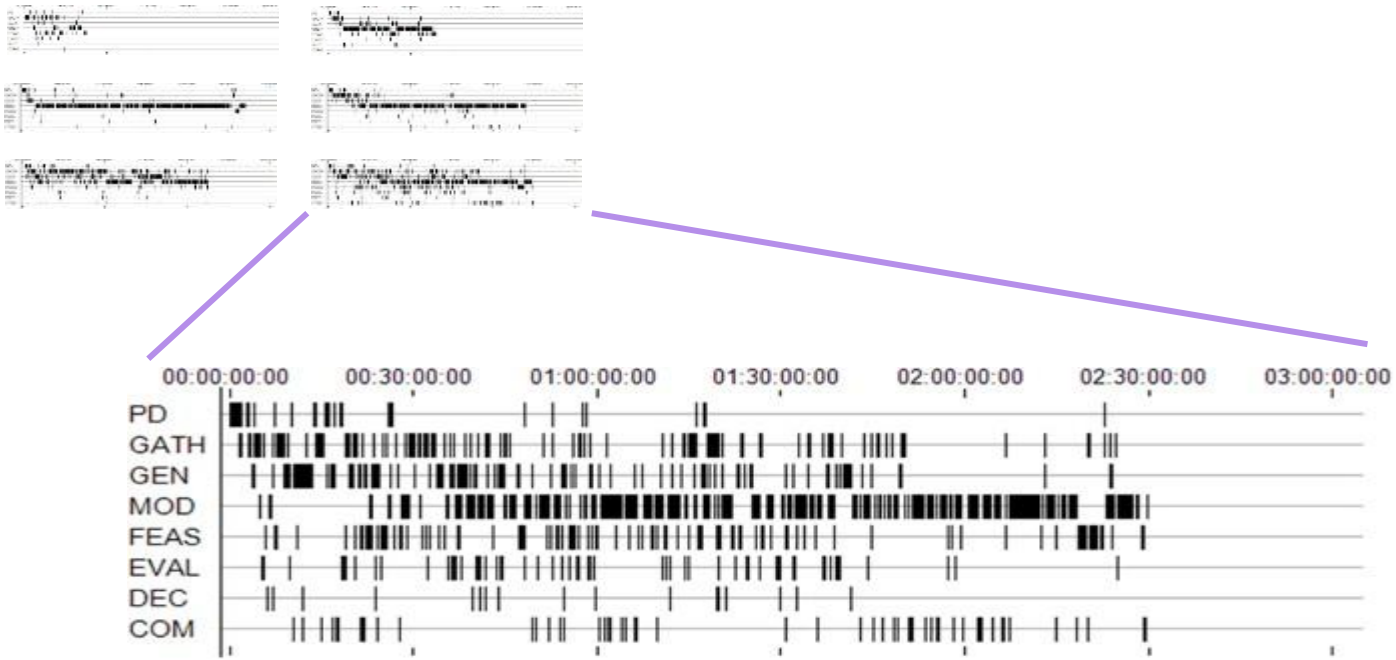
Identification of a need
Implementation

…Identification of a need



Implementation…

Timelines as canvas for research results



Moving towards more experienced design behaviors

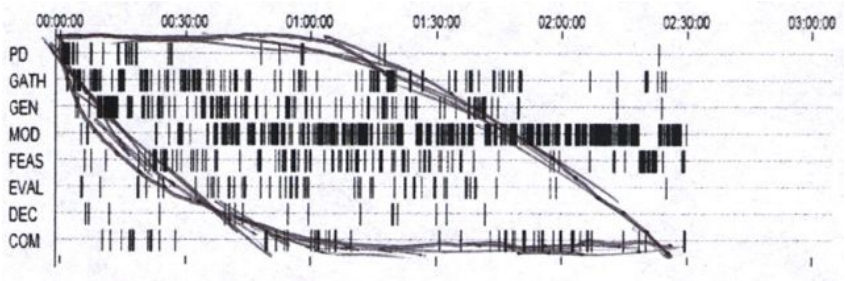
- Thorough problem scoping at the start of the process before turning towards modeling
- Gather information throughout the process
- Transition and iterate throughout the process
- Stay the course at certain times

Moving towards more experienced design behaviors
(also, where to consider context in design)

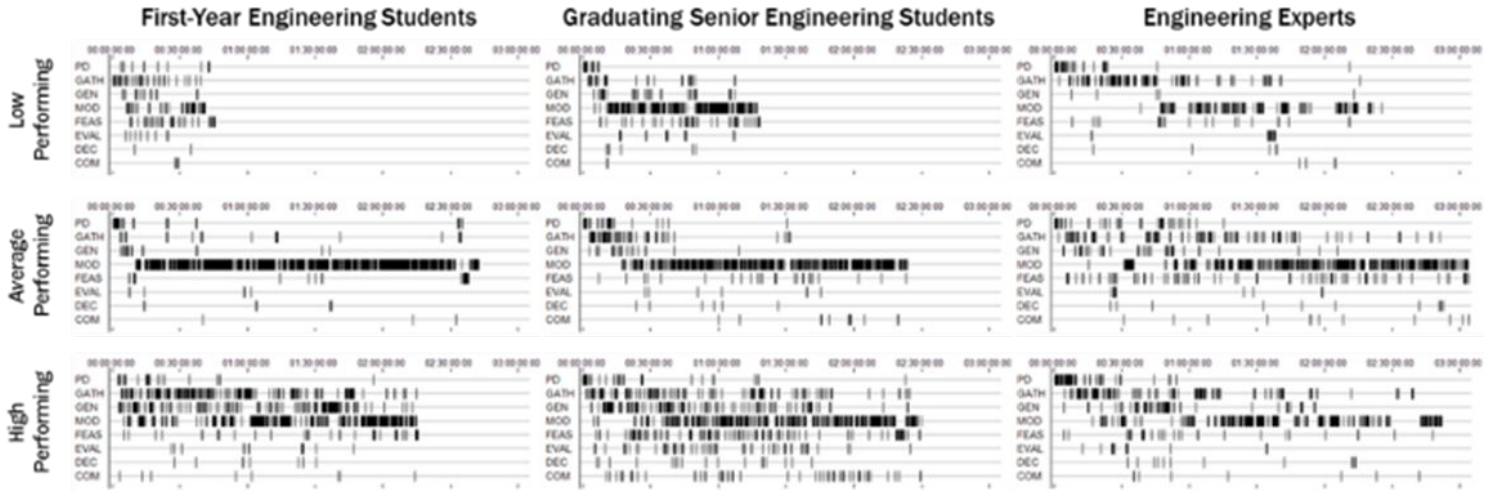
- Thorough problem scoping at the start of the process before turning towards modeling
- Gather information throughout the process
- Transition and iterate throughout the process
- Stay the course at certain times

Moving towards more experienced design behaviors

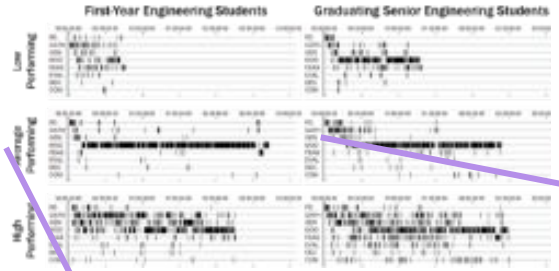
- Cascade shape (ideal project envelope)

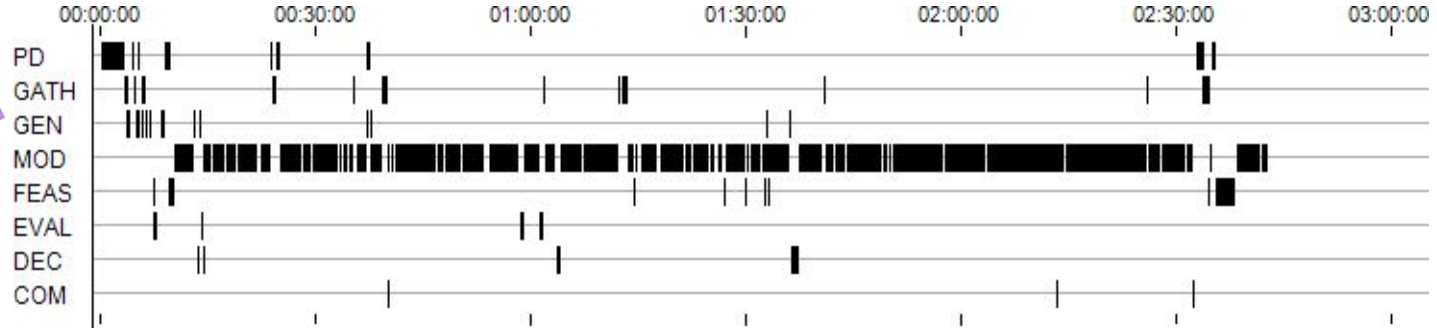


Timelines as canvas: music



Design Soundtracks





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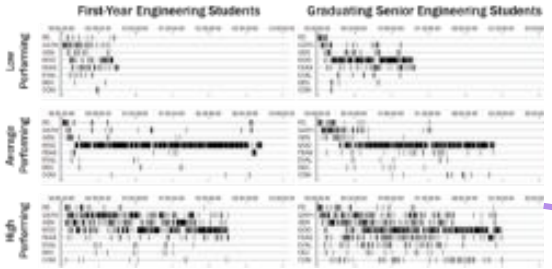
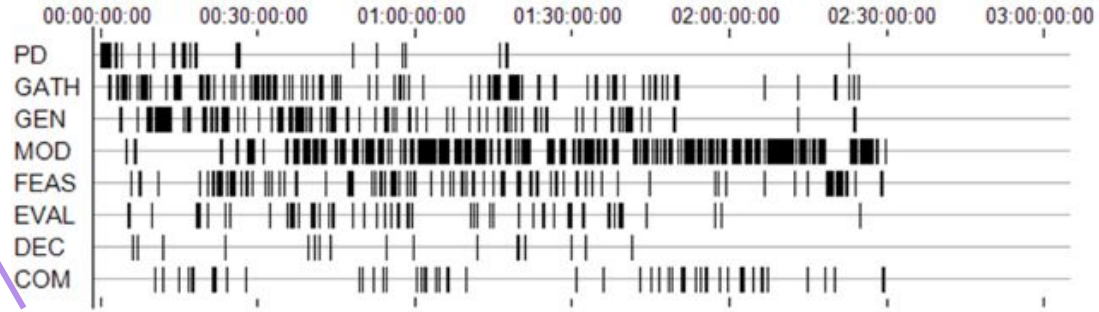
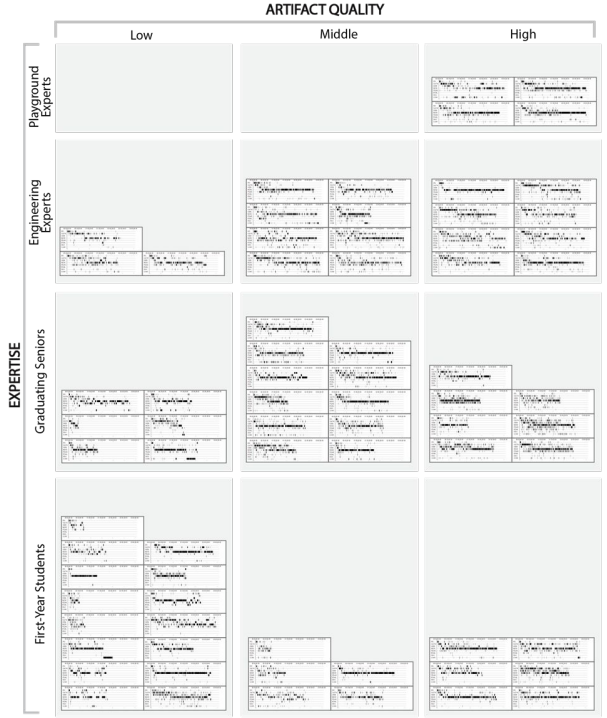




More experience, more complex processes



(Figure from “Design Timelines: Concrete & Sticky Representations of Design Process Expertise”, *Design Studies*, Nov, 2019)

“Magritte Moment”

A pause for curiosities and connections?

The Blank Signature, Magritte

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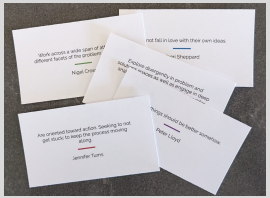
- Design expertise research
- Teaching design
  - Design signatures
  - Good Designers do “X”
  - Dear Design seminar
- Wrapping up



So now what?

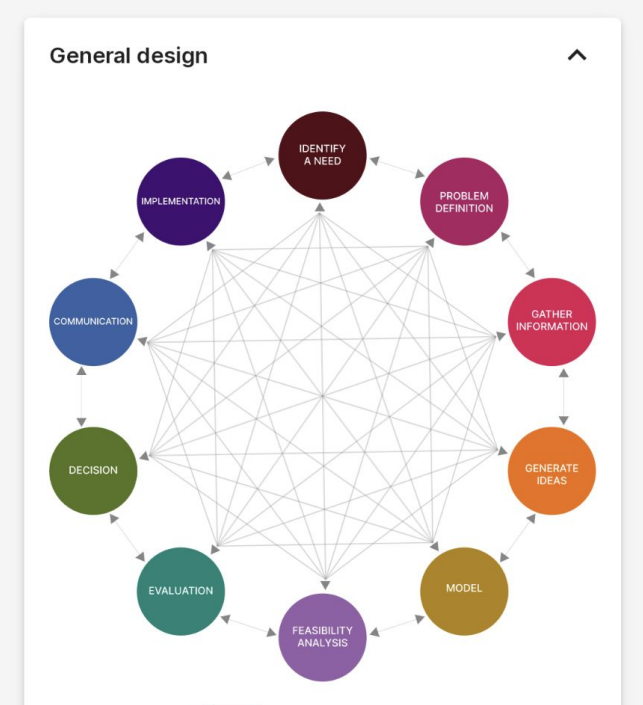
- Revisiting my questions:
  - How do engineering students and experts engage in design?
  - Are there differences that can inform how to teach design?
- Revisiting my ultimate goal:
  - How to teach engineering students to consider context
- My design challenge
  - How can these findings be useful for teaching design?

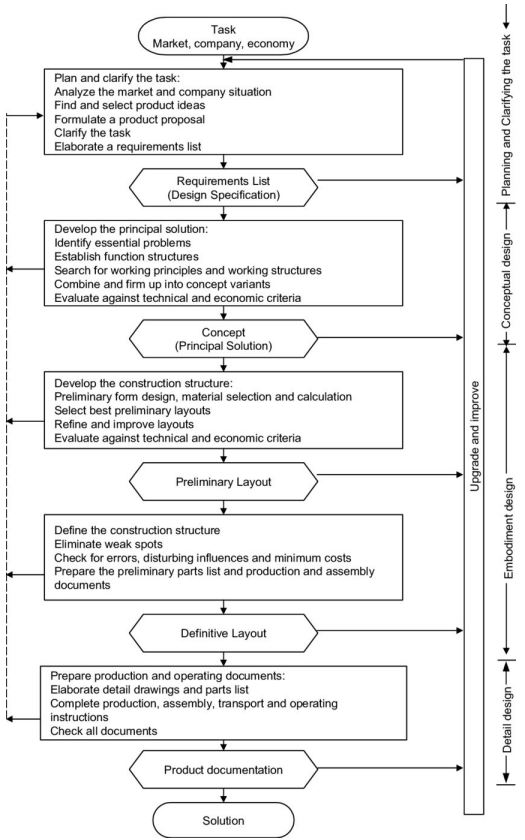
Broad design teaching landscape in engineering education

- Capstone design
- First-year design
- Design spine
- Design projects in many classes
- Maker spaces
- Service learning
- ……

Photos from UW GIX program

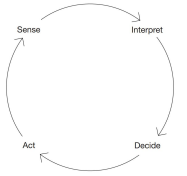
How design can be explained

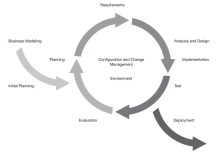


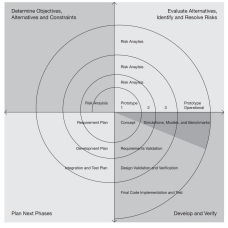


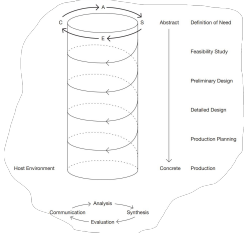
Pahl and Bietz, Engineering Design:
A Systematic Approach, 1999

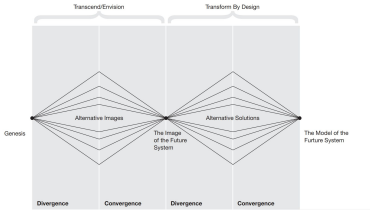
Google search “Design process models”: 949,000,000 (6/29/23)

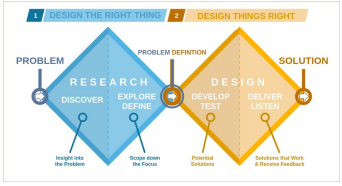


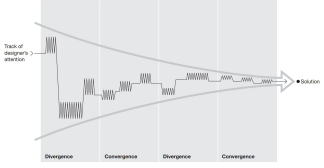


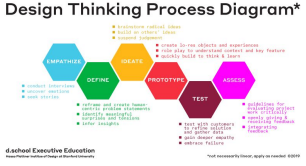


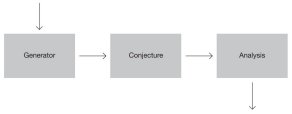


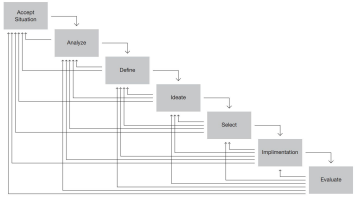


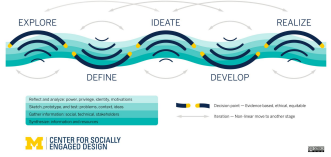


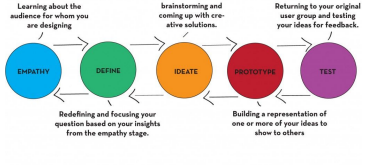


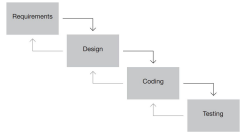


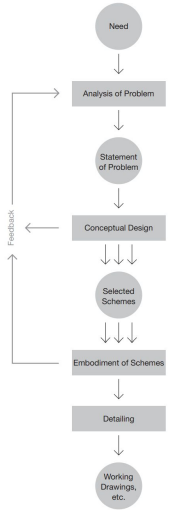












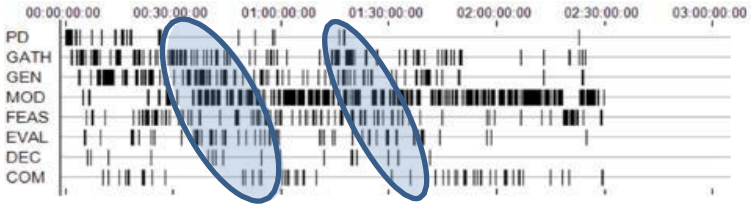
Sources: “How Do You Design: A Compendium of Models (Dubberly); Stanford d.school design model, Hexagon model, accessed 1/24/23, Node/arrow model, accessed 3/10/21; Double Diamond Model, British Design Council, 2005; Socially Engaged Design Process Model, University of Michigan, accessed 1/24/23

Recalling...

“All models are wrong, some are useful”

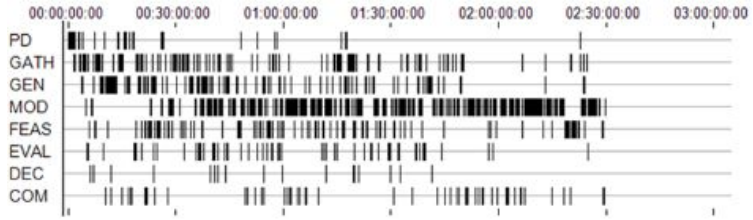
~ George Box

Affordances of timelines: Abstract concepts made visible



PD: Problem Definition
GATH: Gathering Information
GEN: Generating Ideas
MOD: Modeling
FEAS: Feasibility
EVAL: Evaluation
DEC: Decision
COM: Communication

Teaching with timelines: ME student



What was the most important thing that you learned today? Why?

Super valuable! Much more compelling to see real data, detail, makes me believe, instead of tuning out "prescribed" info, can't trust how they derived it b/c don't know. Spend another day in our class talking about this research, please!

"Super valuable! Much more compelling to see real data, detail, makes me believe, instead of tuning out "prescribed" info, can't trust how they derived it b/c don't know. Spend another day in our class talking about this research, please!"
(Mechanical engineering student)

Teaching with timelines: CE student

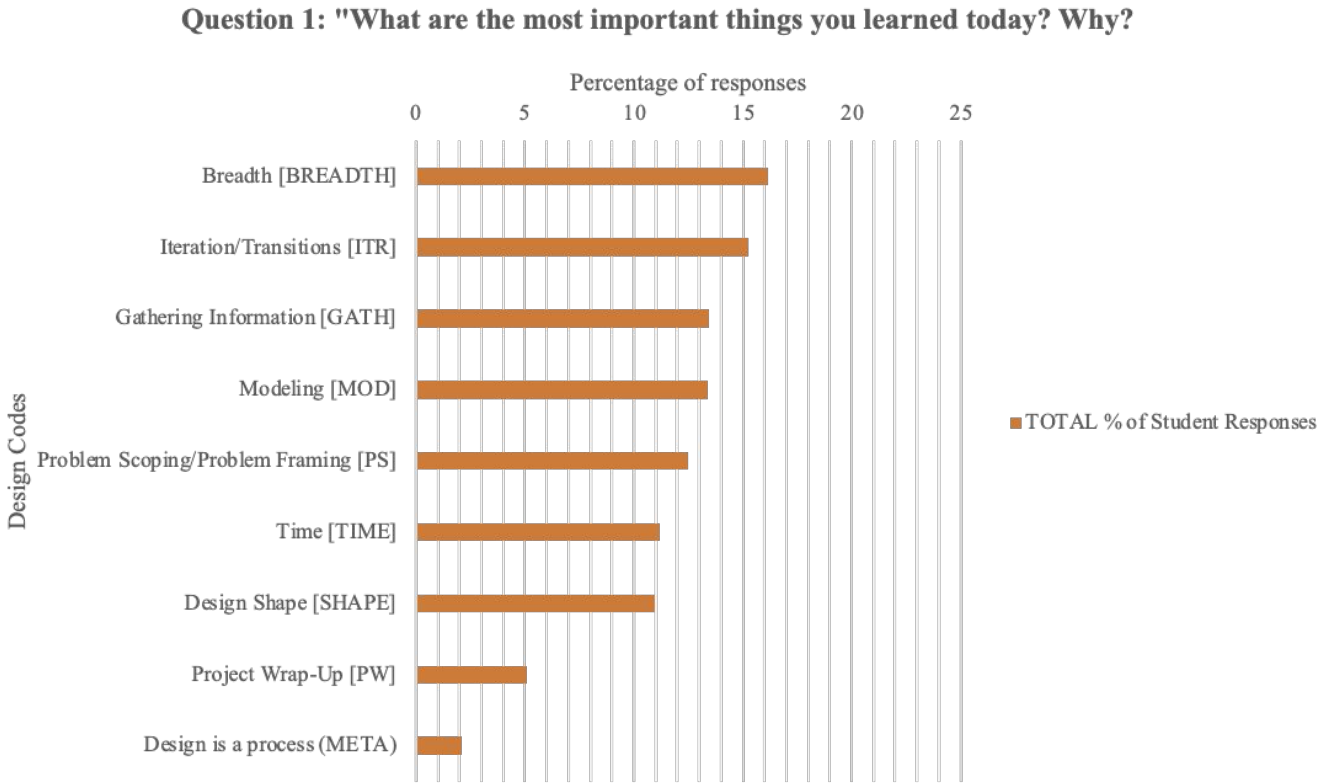
"Realizing that taking your time is important, realizing that higher quality designs gather data and define the problem more thoroughly BEFORE modelling which is SO COOL to see as statistically relevant because now I can PROVE to people that understanding the problem FIRST is crucial for success."
(CE student)

Teaching with timelines: CE student

"Realizing that taking your time is important, realizing that higher quality designs gather data and define the problem more thoroughly BEFORE modelling which is SO COOL to see as statistically relevant because now I can PROVE to people that understanding the problem FIRST is crucial for success."
(CE student)

"A problem well stated is a problem half solved"
Prof. Kazuo Yamamoto
President, AIT

Teaching with timelines: Student reactions



Translating research into practice

- Students make great observations when they engage with the research
  - But will it affect their design practice?
- Next challenge:
  - Make learning active
  - Invite students to see and own their design processes

Teaching design - three slices

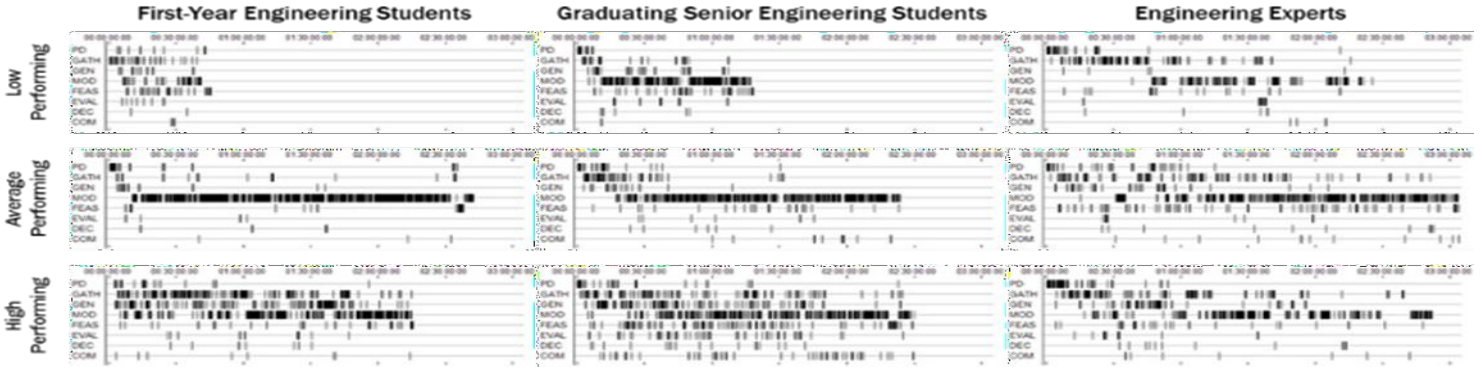
- Teaching design
  - Design signatures - focusing on design process
  - Good Designers do “X” - casting a wide net on design
  - Dear Design seminar - situating design process in the wider net of design

Agenda

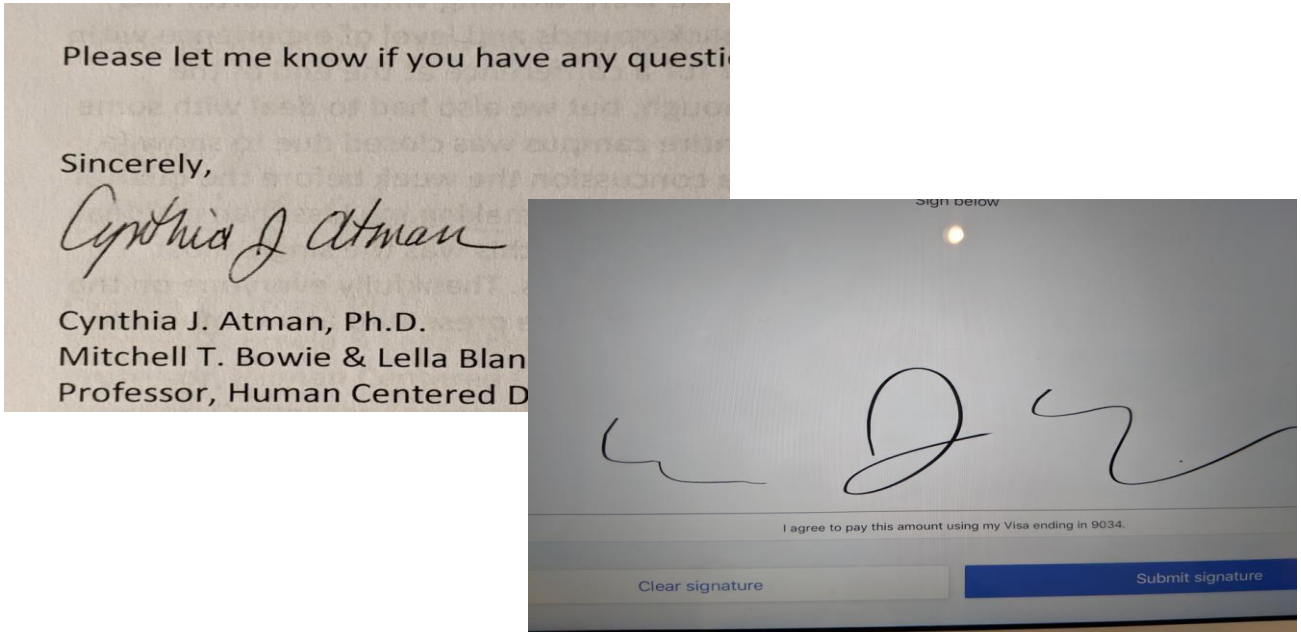
- Setting the stage
- Design expertise research
- Teaching design
  - Design signatures
  - Good Designers do “X”
  - Dear Design seminar
- Wrapping up

Timelines as canvas:

…design traces…design signatures

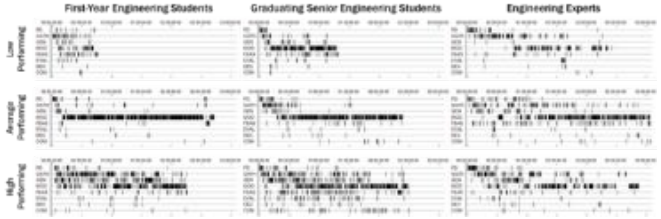


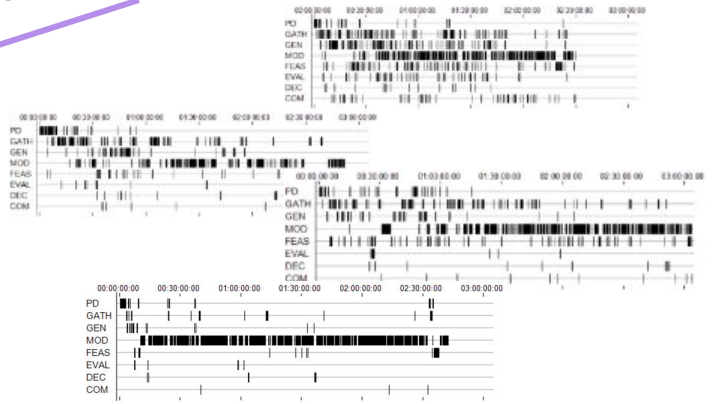
Signatures can vary according to function



Design signatures as organizing principle

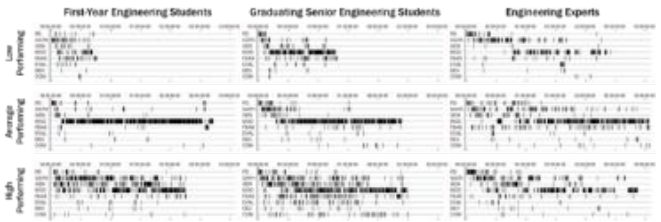
- Plan new projects
  - Choose a design signature you aspire to follow

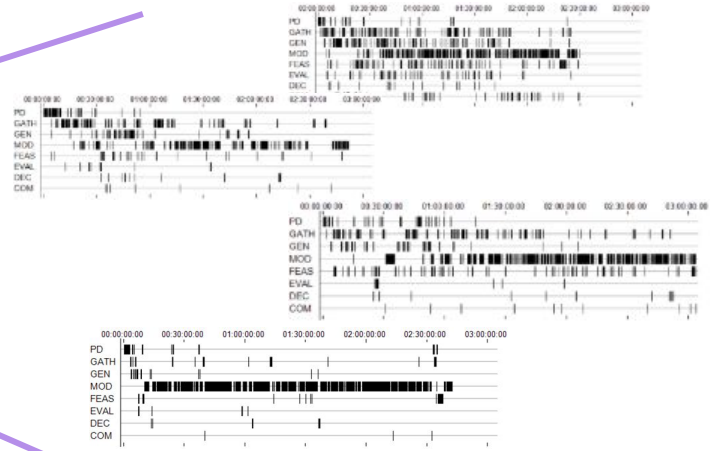




Design signatures as organizing principle

- Use it as a guide to monitor your process
- Reflect - how did you do?

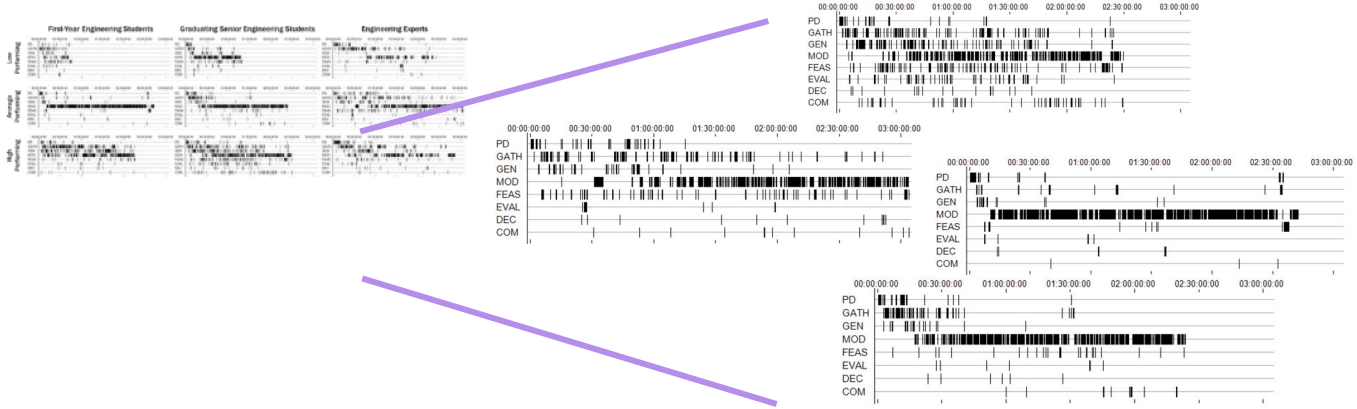




Design signatures as organizing principle

- Gymnast Simone Biles has a signature balance beam move
- Do you have a typical way you engage in design?

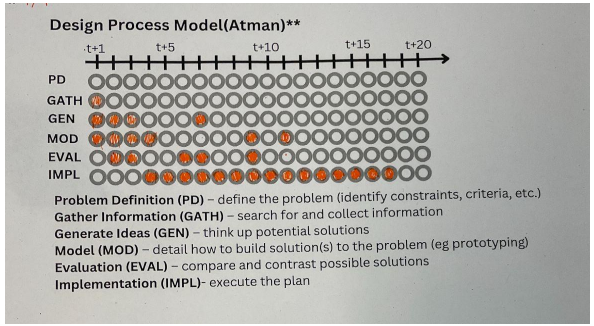
➜ Do you have an *aspirational design signature?*

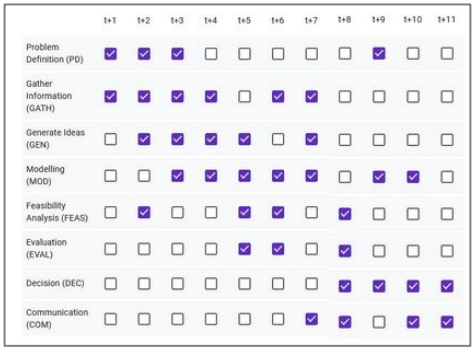


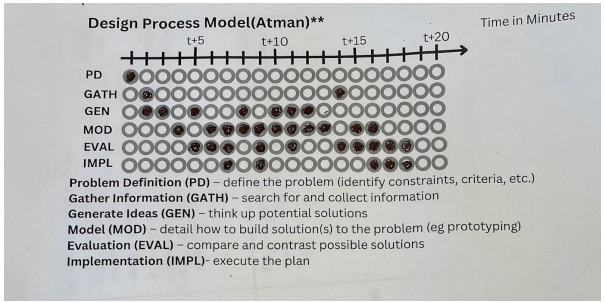
Next steps

- Create opportunities for students to “live” their design signatures
  - Active experience
  - Opportunities to reflect
- Help make the invisible visible

Making the invisible visible: Bubble sheets & Google forms



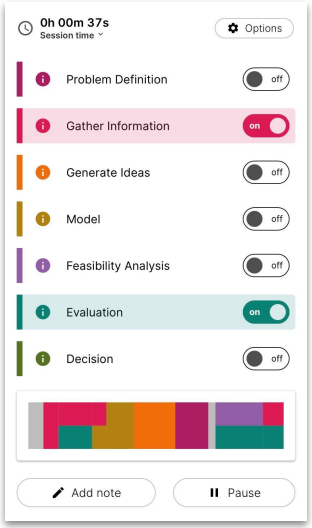


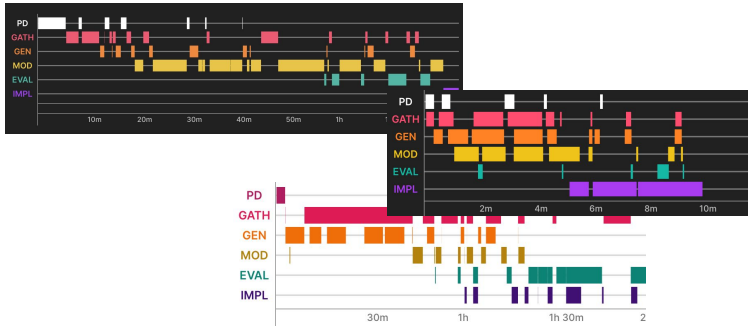


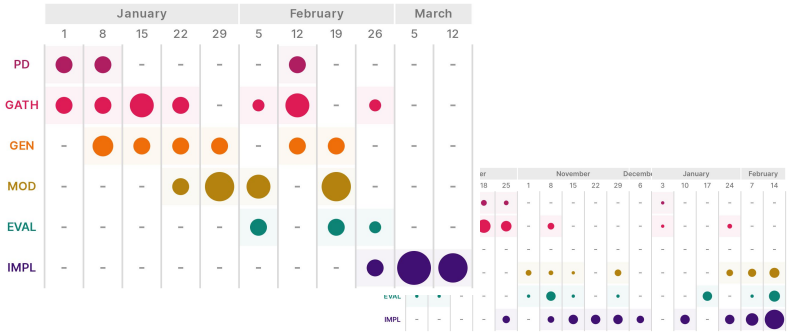
Inspired by DEED "Design Fishbowl" Workshop, presented by Alan Chong and Jason Foster at the 2011 ASEE Annual Conference and Exposition, Vancouver, B.C., June 2011

Capturing Design Signatures: Design Signatures App

Jordan Yoon-Buck
Shiva Anem
Grace Barar
Khadijah Jordan
Rylie Sweem
Nicole Washington
Kathryn Shroyer





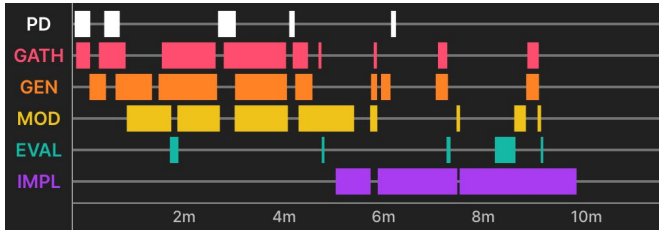


[Design Signatures App]

Design Signatures App

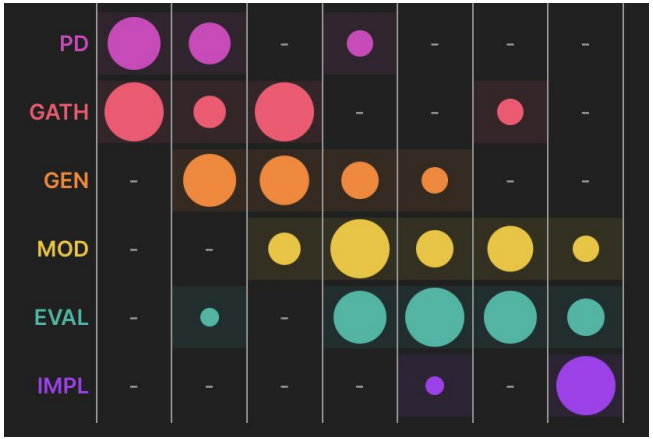
Synchronous tracking

(shorter projects)



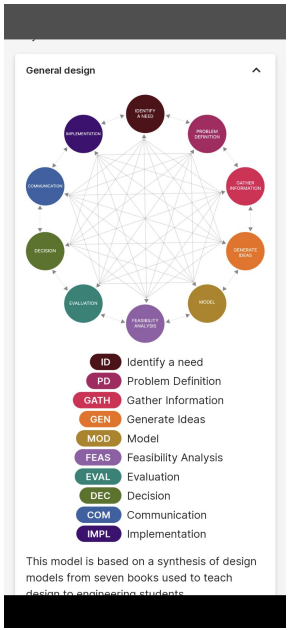
Asynchronous tracking

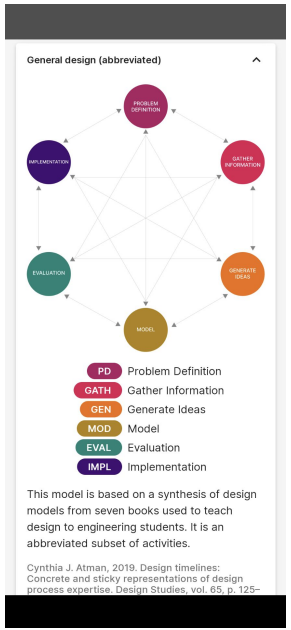
(longer projects)

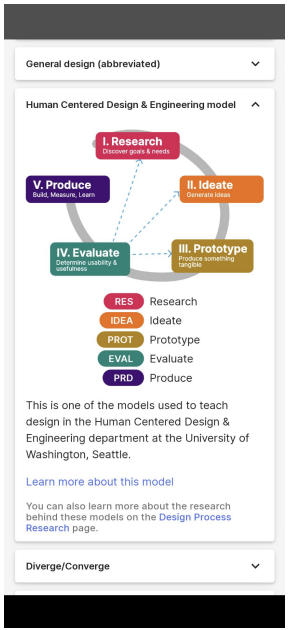


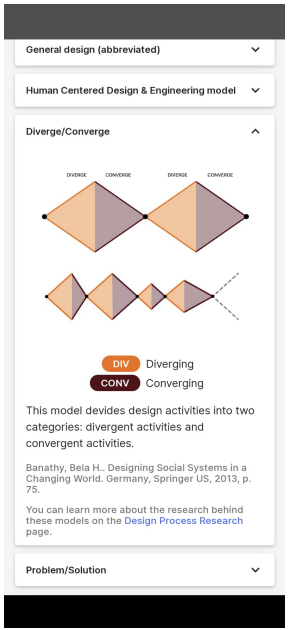
[Design Signatures app]

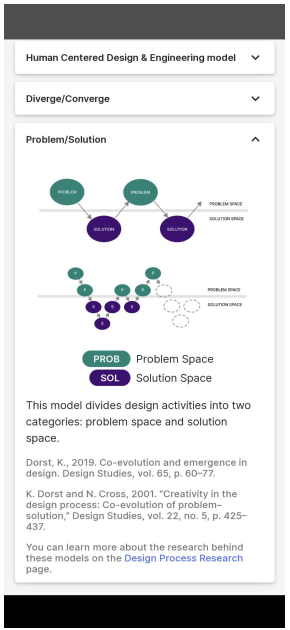
Design Signatures App: Input your own model

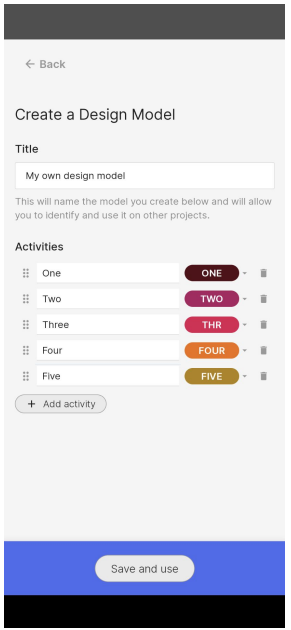






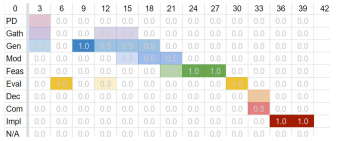




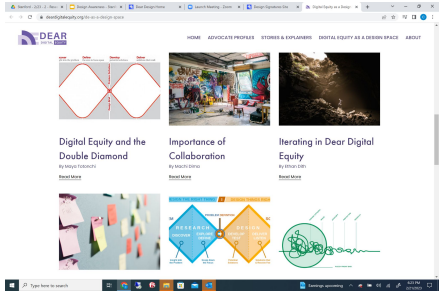


Design Signatures in the Wild

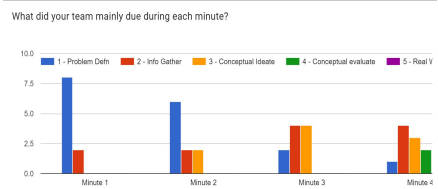
- Reid Bailey, University of Virginia
- Dharma Dailey, UW Bothell & UW Seattle (eScience Institute)
- Susannah Howe, Smith College
- Nadia Kellam, Arizona State University
- Daria Kotys-Schwartz, University of Colorado, Boulder
- Micah Lande, South Dakota School of Mines
- Eli Patten, UW Seattle, Mechanical Engineering
- Linda Vanasupa, Olin College
- UW CELT team
    - Cindy Atman
    - Eileen Zhang (undergraduate student)
    - Yuliana Flores (graduate student)
    - Jennifer Turns



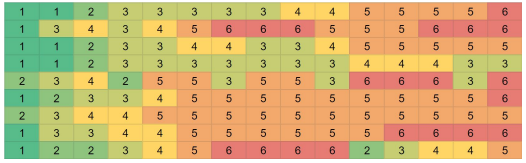
Eli Patten



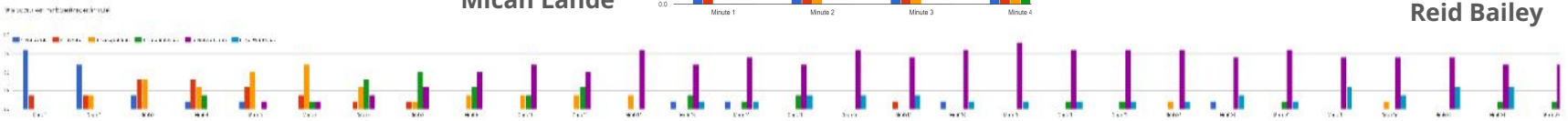
Dharma Dailey



Micah Lande



Reid Bailey



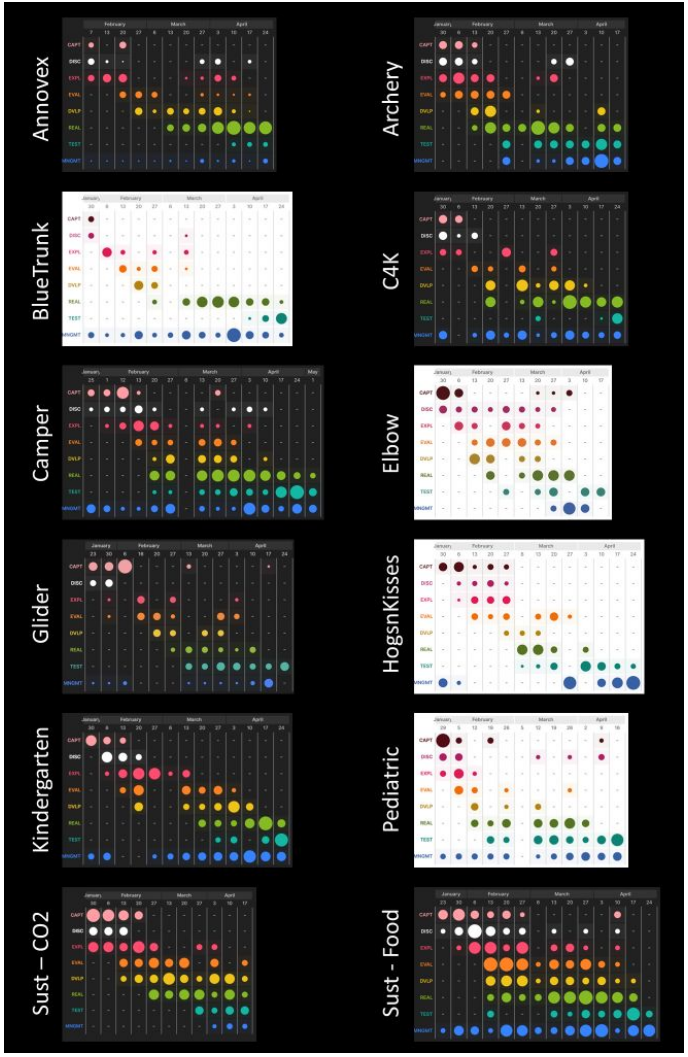
12 minute design challenge: Student user-researchers code design team

Semester-long capstone design project

Design Timelines

show activities over the project duration

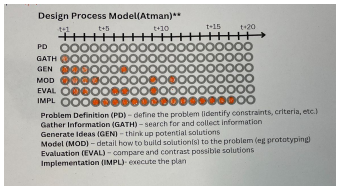
Root Problem Identification	Capture	Gather information about a problem
	Discover	Define the problem
Conceptual Solutions	Explore	Generate possible solutions
	Evaluate	Analyze, compare, select possible solutions
	Develop	Flesh out selected designs
Built Solutions	Realize	Prototype, implement, build
	Test	Evaluate implemented solutions
	Manage	Activities with no direct connection to design activities

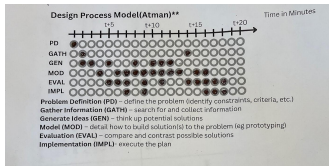


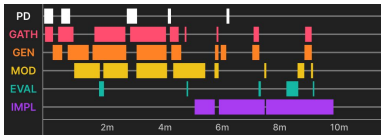
Reid Bailey, University of Virginia, May 2023

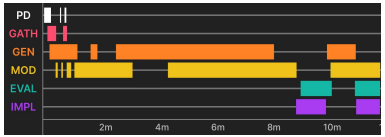
Design signatures as boundary objects

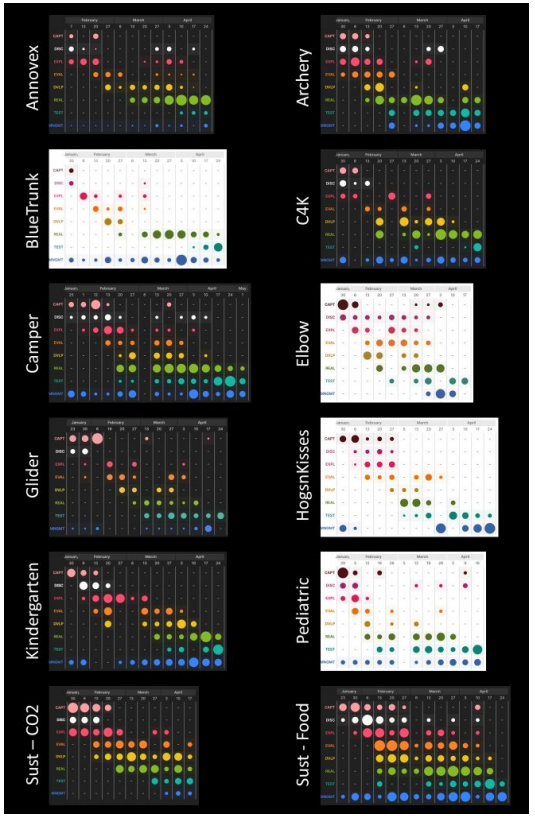
- Make invisible processes visible
- Plan & monitor new design projects
- Reflect:
  - See patterns over time
  - Compare to expert design behaviours
- Enable conversations
  - Among team members
  - Across projects



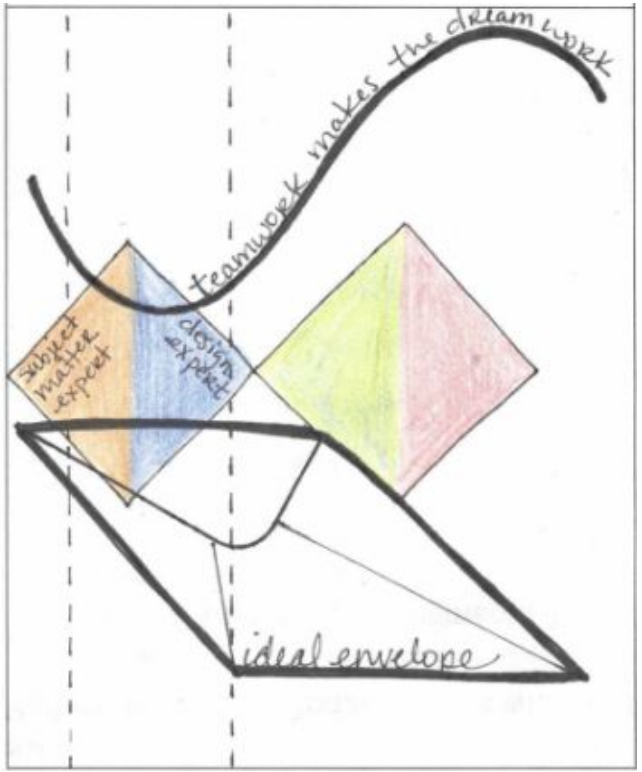


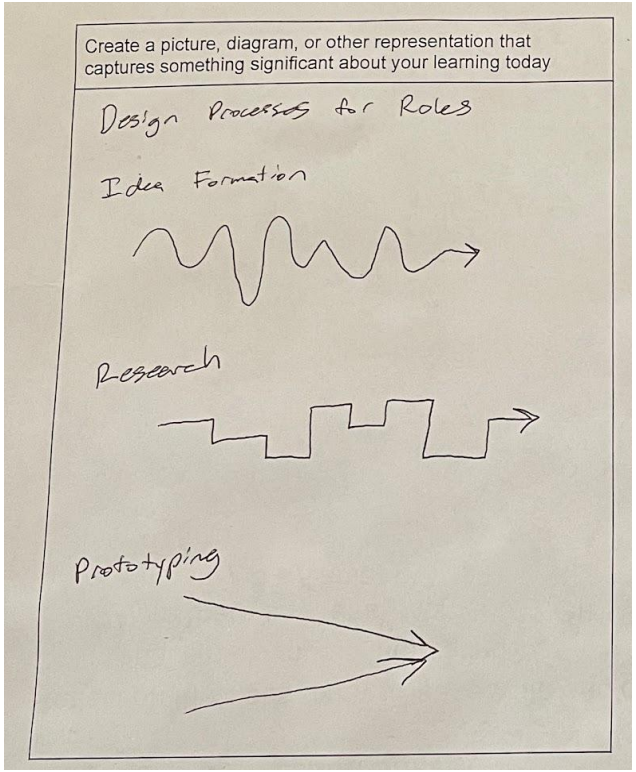






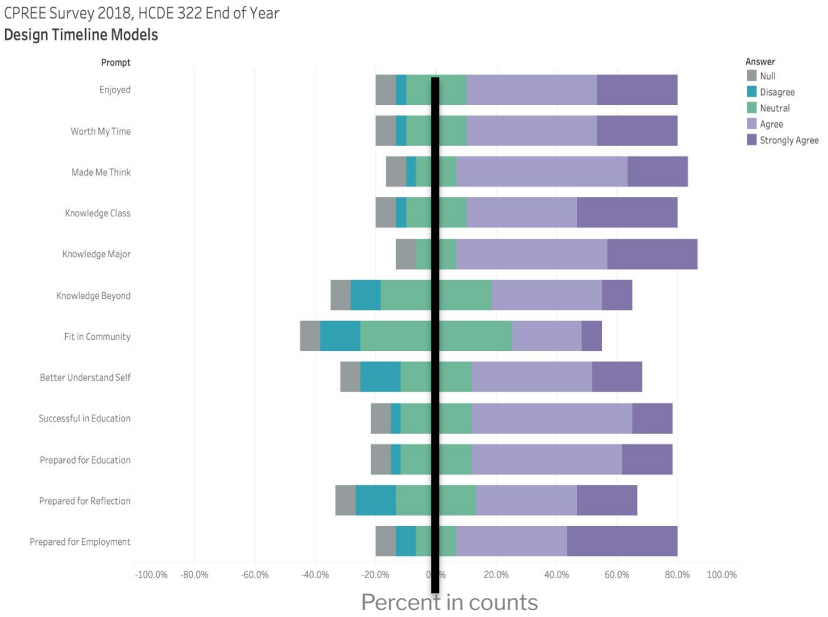
Design signatures: Student reactions



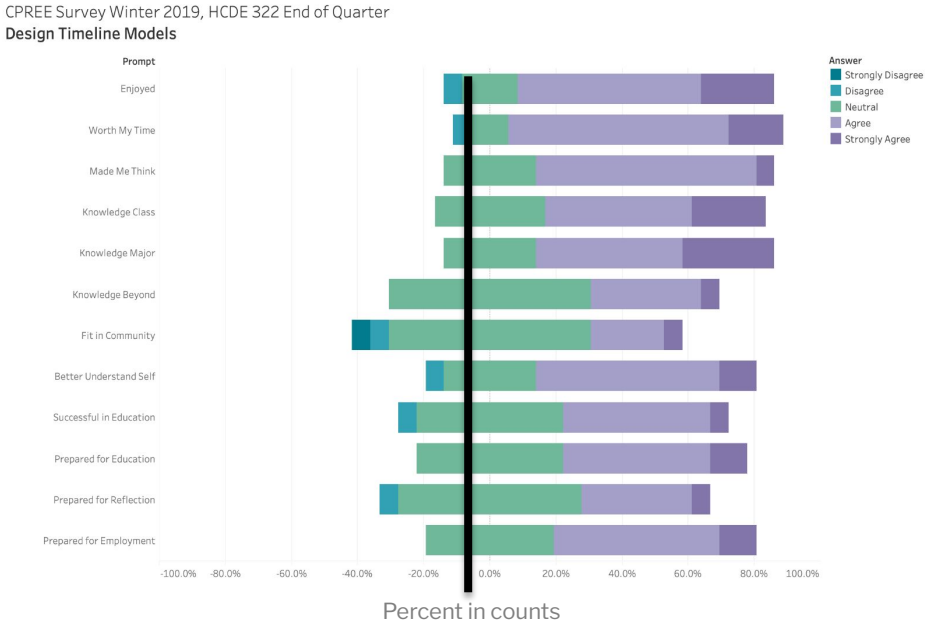


Casey Kelly

Design signatures: Evidence of impact

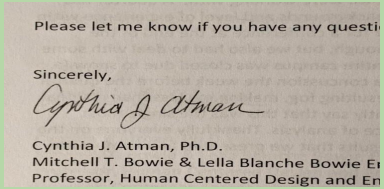


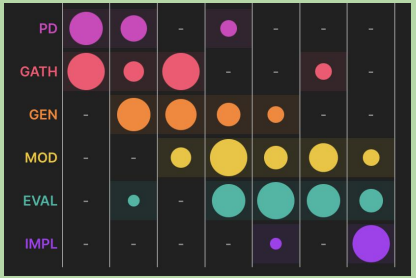
2018 (n=30)

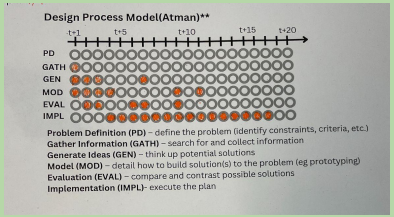


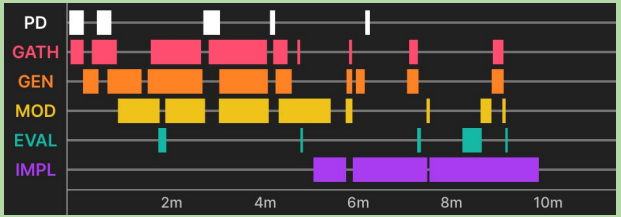
2019 (n=18)

did I learn something useful, was it worth my time...









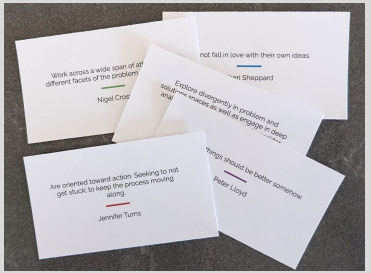
The Blank Signature, Magritte

“Magritte Moment”

A pause for curiosities and connections?

Agenda

- Setting the stage
- Design expertise research
- Teaching design
  - Design signatures
  - Good Designers do “X”
  - Dear Design seminar
- Wrapping up



The landscape of design includes so much more than design processes

Crowdsourcing breadth: Good Designers do “x”

- Asked design researchers and educators to respond to the prompt:
  - When you talk to someone and say “Good designers do ‘X’”, what are the top 4 or 5 things you list?
  - I’m looking for “off the top of your head” answers
- 28 scholars responded with 140 statements
  - Design researchers and educators
  - Engineering design researchers and educators

Good Designers do “X” contributors

- **Robin Adams,** *Purdue University*
- **Cindy Atman,** *University of Washington*
- **Reid Bailey,** *University of Virginia*
- **Adam Carberry,** *Arizona State University*
- **Nigel Cross,** Emeritus, *The Open University, England*
- **Dharma Dailey,** *University of Washington*
- **Shanna Daly,** *University of Michigan*
- **Andy Dong,** *Oregon State University*
- **Liz Gerber,** *Northwestern University*
- **John Gero,** *UNC, Charlotte*
- **Gabi Goldschmidt,** *Technion - Israel Institute of Technology*
- **David Hendry,** *University of Washington*
- **Susannah Howe,** *Smith College*
- **Micah Lande,** *South Dakota School of Mines*
- **Peter Lloyd,** *T U Delft, Netherlands*
- **Janet McDonnell,** Emerita, *Central Saint Martins, England*
- **Laura Murphy,** *University of Michigan*
- **Eli Patten,** *University of Washington*
- **Ben Shneiderman,** *University of Maryland*
- **Sheri Sheppard,** *Stanford University*
- **Lauren Thomas Quigley,** *IBM Research*
- **Jennifer Turns,** *University of Washington*

Good Designers do “X”: Sample responses

- Are constantly learning – about problems, about possible solutions, new skills ~ Reid Bailey
- Take a broad systems approach to the given problem, rather than accepting narrow problem criteria ~ Nigel Cross
- Consider planetary limitations in their work ~ David Hendry
- Attend to the ethics of their professional actions ~ Janet McDonnell
- Understand that every design decision impacts a person's life, even if they can't witness the impact themselves ~ Laura Murphy
- Do not fall in love with their own ideas ~ Sheri Sheppard
- Include as many people in the process as possible; they make design social ~ Jennifer Turns

Good Designers do “X”: Many possible groupings

- Are intentional about process

- Attend to problem framing
- Understand the broad context of situation
- Include many perspectives
- Understand users and stakeholders

- Understand attributes of their solutions
- Think about consequences of design

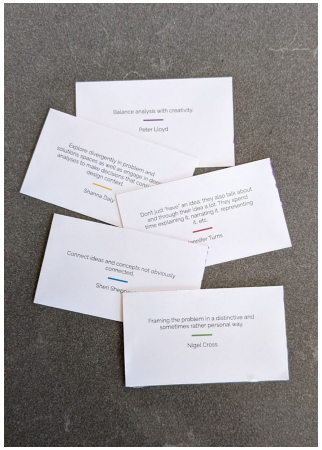
- Make the world a better place
- Have developed a personal design mindset/stance

- Ask questions / take a learning perspective
- Have a systems approach / deal with complexity
- Incorporate ethics/values

- Work with others

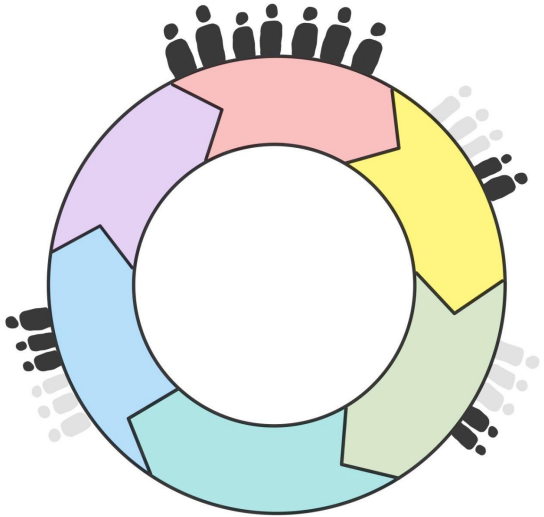
Exploring Good Designers do “x” statements

- You have an envelope with 5 cards from different people
- Choose one that resonates with you and share it with your neighbor
- Discuss how these cards might link to transdisciplinary engineering



Good Designers do “X”in the classroom

Good Designers do “X”: Student representations



Dear Design

Title: Design Inspirations

Inspirations: consider stakeholders

How to read:

- color: design activity
  - Problem definition
  - Gather information
  - Generate ideas
  - Modeling
  - Evaluation
  - Implementation
- : stakeholders who are involved in the process
- : stakeholds should have been included in the design process

Dear Design

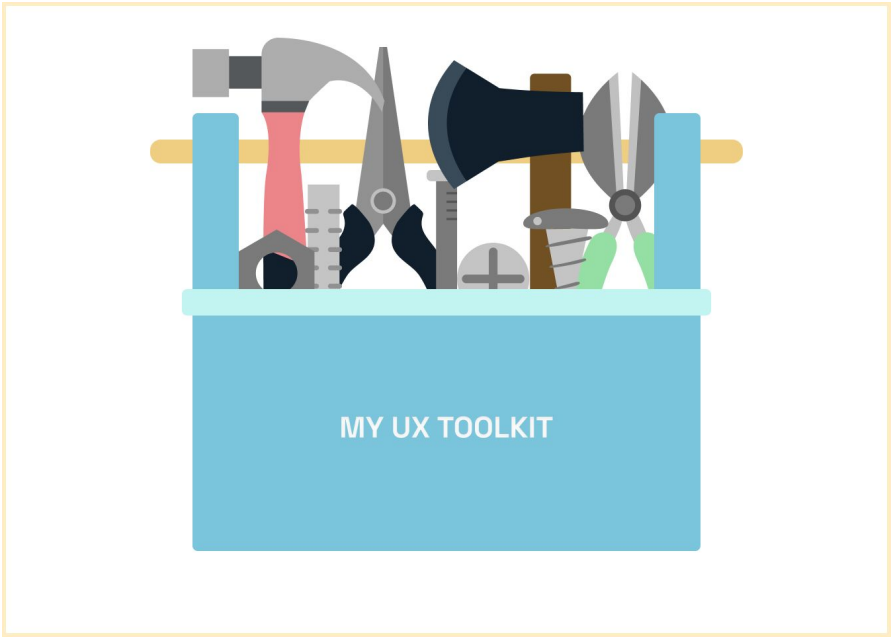
Human Centered Design & Engineering

University of Washington

Seattle, WA 98105

Christina Kwo

Good Designers do “X”: Student representations



Dear Design

Week 8: Design Inspirations

Design Activity: Inter/multi disciplinary considerations & mindset -
“know that disciplinary thinking and first-principles in design are not simply about natural sciences and economics but also include ethics and social sciences”

How To Read:

Dear Design
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Pallavi

Good Designers do “X”: Student reflections

Use a **picture, diagram, or other representation** that captures something significant about your learning today

Agenda

- Setting the stage
- Design expertise research
- Teaching design
  - Design signatures
  - Good Designers do “X”
  - Dear Design seminar
- Wrapping up

The landscape of design includes so much more than design processes

Dear Design seminar: Postcards of design processes

- Inspired by Lupi & Posavec's book *Dear Data*
- Goal: help students develop "design awareness"
  - Be reflective designers
  - Develop their unique design identity
- 10 week virtual seminar, each week:
  - Engage in a design process (or use previous capture)
  - Discuss design from a different lens (many models, design expertise, good designers do "X")
  - Represent their process on a postcard
- Final postcard: their Ideal (Aspirational) Design Signature

Grace Barar, Yuliana Flores, Khadijah Jordan, Kathryn Shroyer

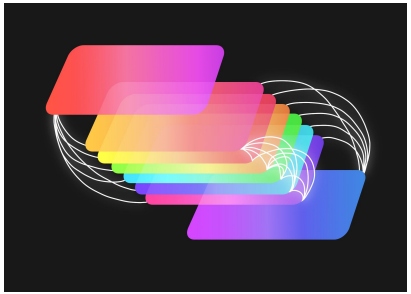
Lupi, G., & Posavec, S. (2016). *Dear data*. Chronicle books.

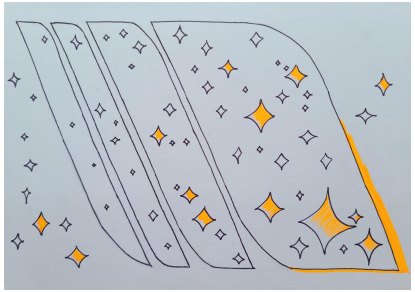
Dear Design Seminar topics by week

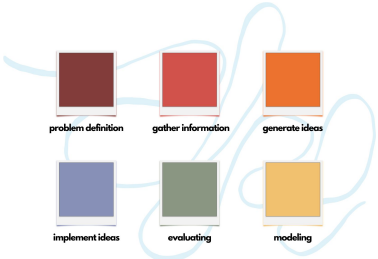
Week	Nuts & Bolts	Design Process Models	Broader Design Context
1			What counts as design?
2		Coding design activities	
3	Capturing design		
4	Representing design		
5			“Design awareness” questions
6		Many design models	
7		Design expertise research	
8			Good designers do “X”
9			Aspirational design signatures

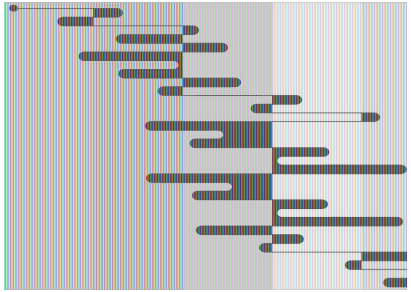
Dear Design Seminar

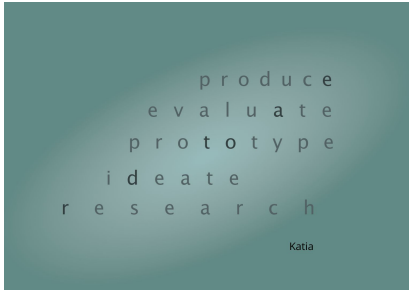
Aspirational Design Signatures

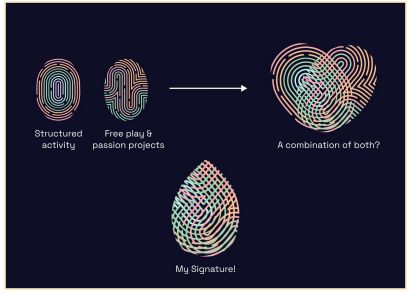


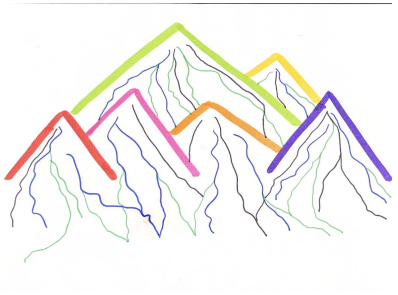








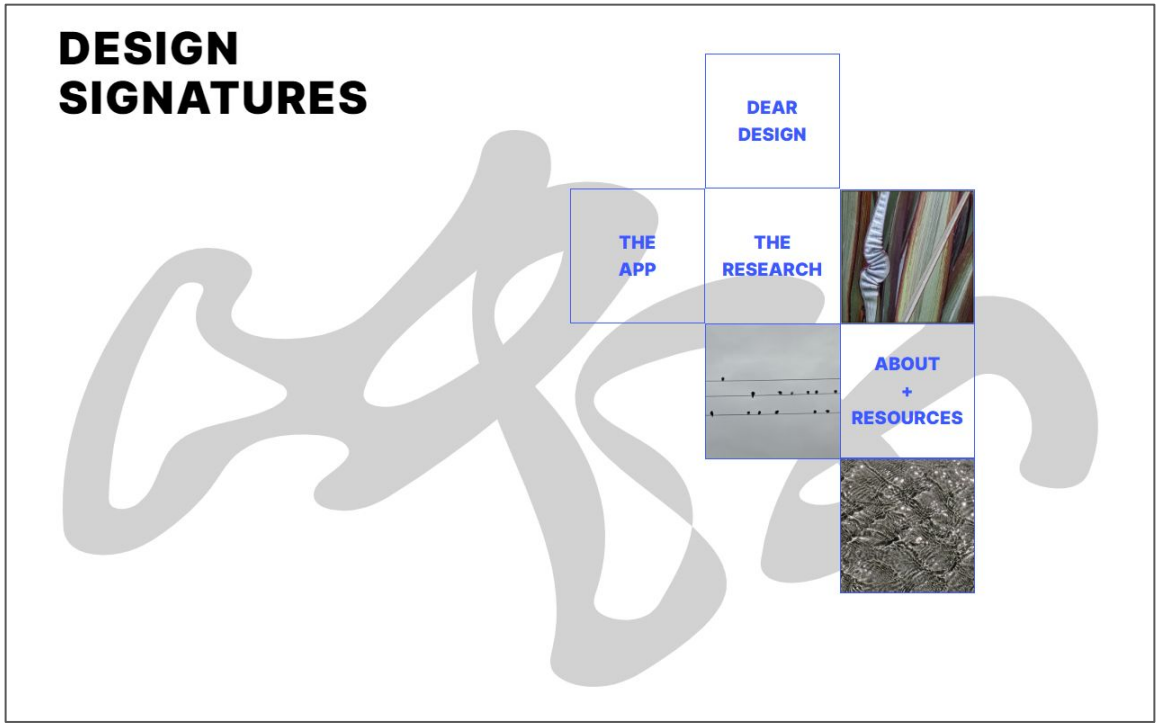




Inspired by “Dear Data” project: Lupi, G., & Posavec, S. (2016). *Dear data*. Chronicle books.

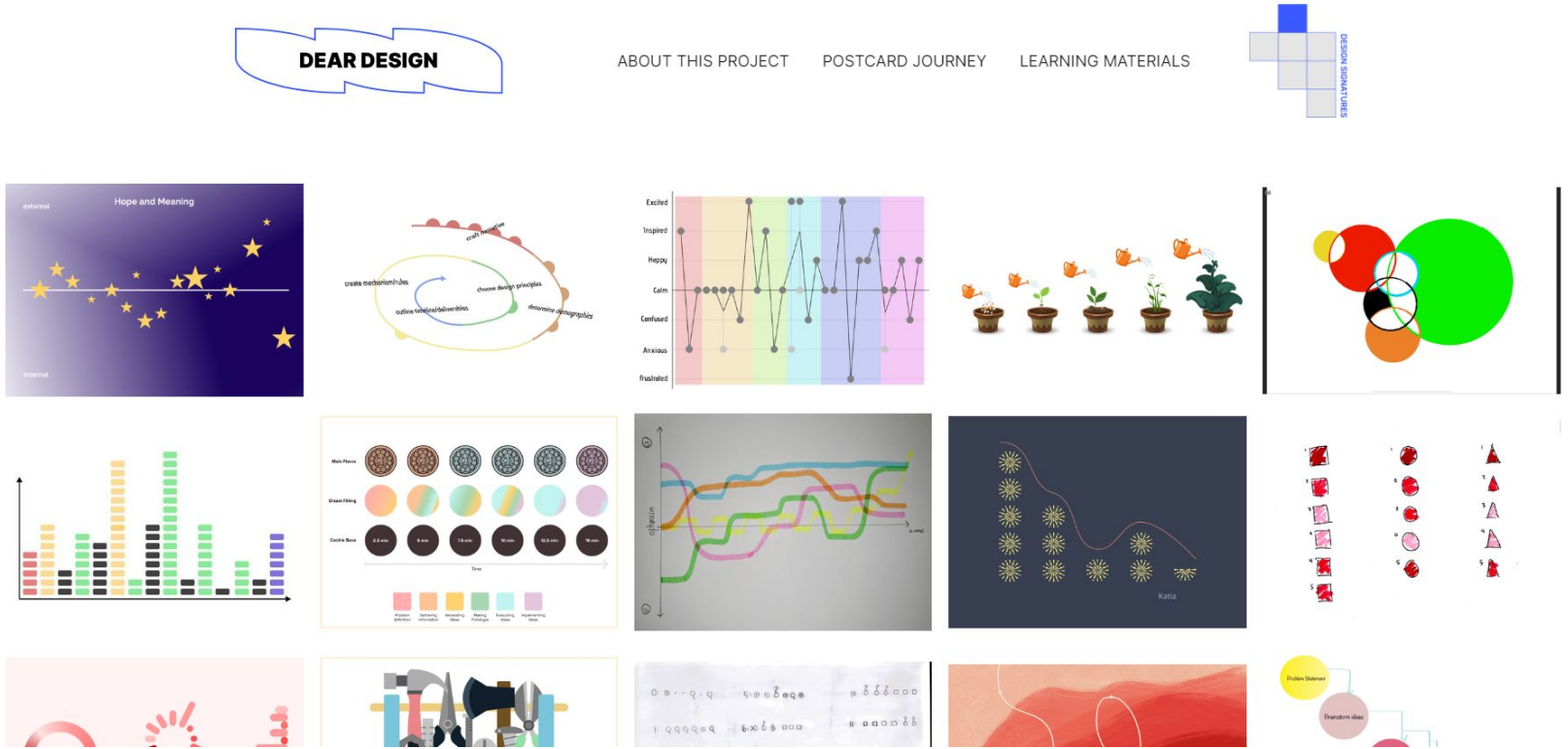
Website

designsignatures.org



Grace Barar, Yuliana Flores, Eileen Zhang

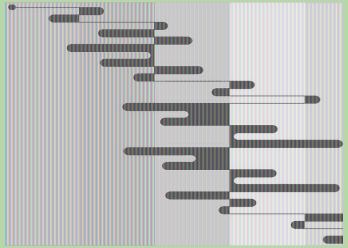
Design Signatures website



Dear Design: Survey, 2 months after seminar

Has participation in Dear Design affected how you currently do design? How?

- Yes! Now **I find myself planning or preparing before diving into design.** I try to find inspiration, experiment before I start something as opposed to “just starting” - something I used to do
- I pay **way more attention to my process while I am in it not just at the beginning** and leave it.
- Participation in Dear Design has made me **feel very strongly like a designer with purpose and intent, and so I feel much more confident and secure when I do design…**



"Good designers don't fall in love with their own ideas"
~Sheri Sheppard

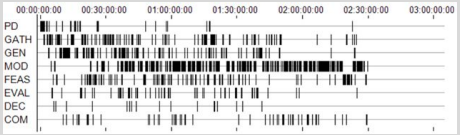
"Magritte Moment"

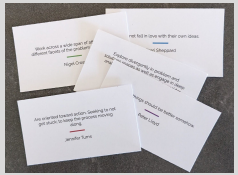
A pause for curiosities and connections?

The Blank Signature, Magritte

Agenda

- Setting the stage
- Design expertise research
- Teaching design
  - Design signatures
  - Good Designers do “X”
  - Dear Design seminar
- Wrapping up

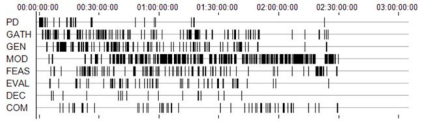


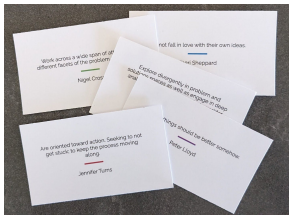


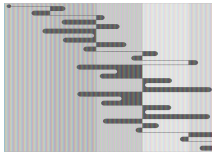
Today's goal:

- Engage with design expertise research results & a list of what "good designers" do
- Come away with one or two things that connect to your work

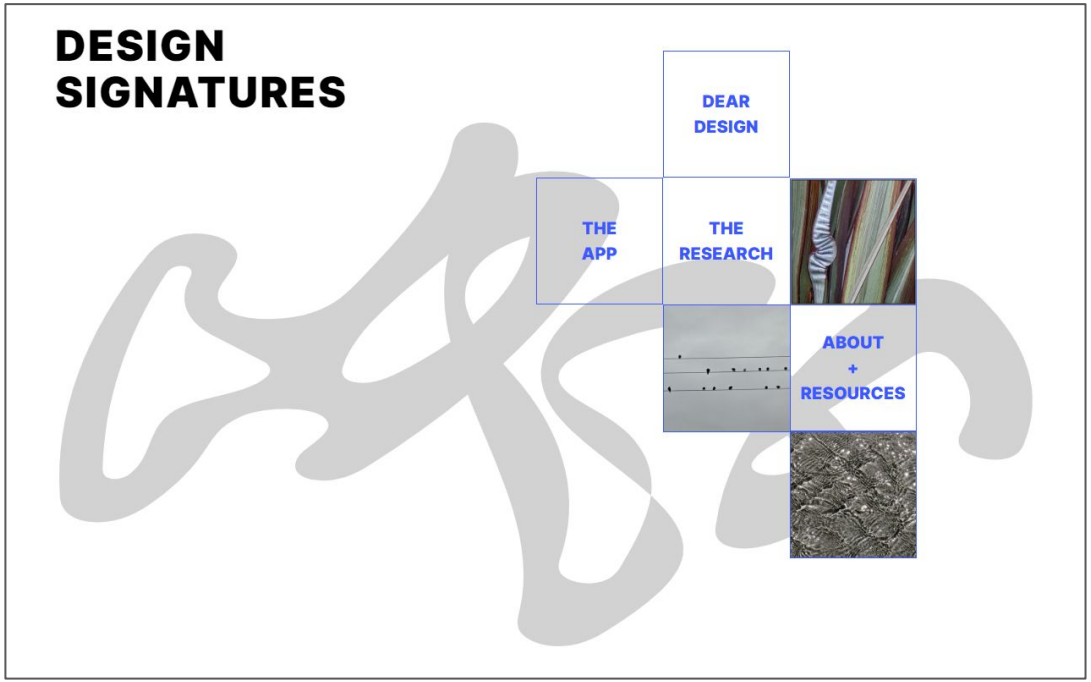
TE 2022 conference paper titles





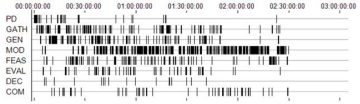


Design Signatures website

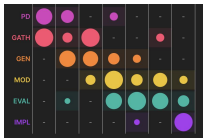


designsignatures.org

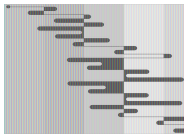
Design Expertise Research



Design Signatures App

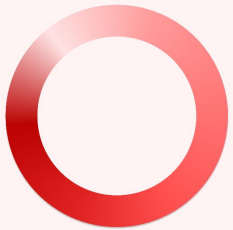


Dear Design Seminar

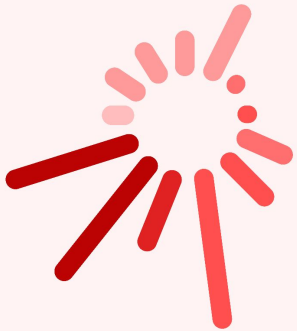


Good Designers do “X” coming end of summer!

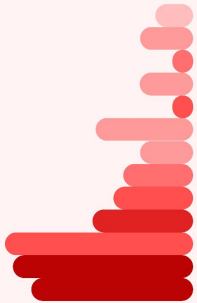
Good Designers do “X”: Student representations



Ethics



Inter/multi disciplinary considerations & mindset



Self-awareness/ reflection

Hsin-Ya Hung

Dear Design
Week 8: Design Resume
Inspirations:

- Self-awareness/ reflection
- Inter/multi disciplinary considerations & mindset
- Ethics

How to read:

- Problem Define
- Gather Information
- Generate Idea
- Modeling
- Evaluation
- Implement

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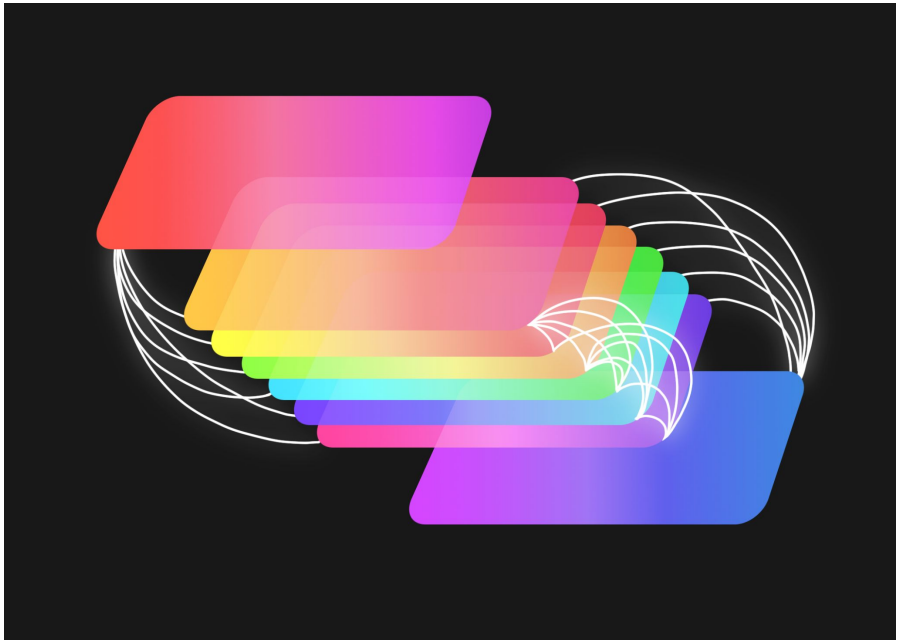
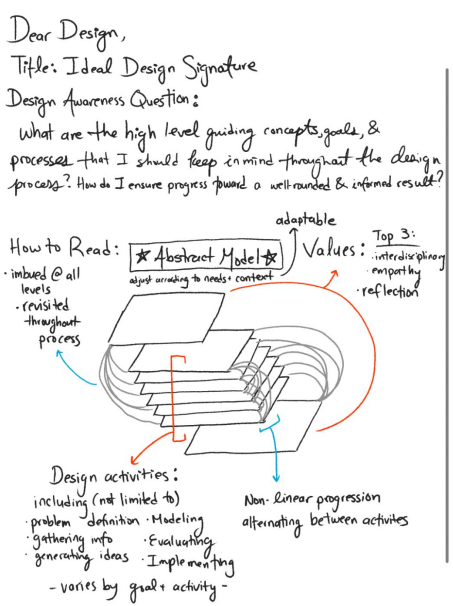
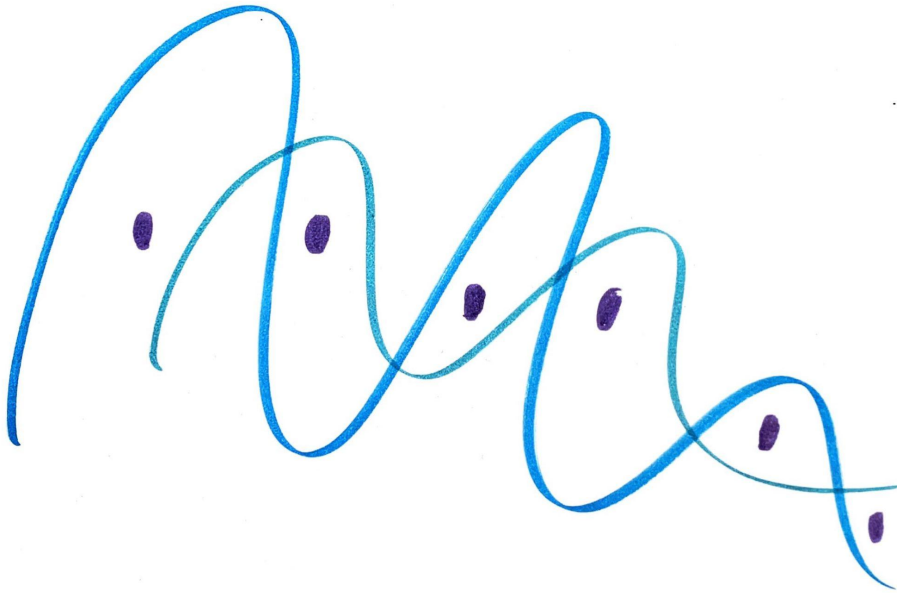
Backup Slides after here

Aspirational Design Signature: Student representations







Dear Design,
Title: Ideal Design Signature

My ideal design signature has a convergent, cascade shape. It includes a nod to the concept of the wave/particle duality. In a design process it is important to be both fluid/open and concrete/decisive, with an interplay of the two.

Key:
- wave - open to input, Gather information, Ideate, Evaluate
- Particle - decisions/down, Model, prototype, implement
- Shape - cascade, convergent, ideal project envelope

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Cindy Atman

Cindy Atman, 2022

Design: A human endeavor

- Who designs?
  - “Everyone designs who devises courses of action aimed at changing existing situations into preferred ones” (Herb Simon, 1969)
  - Going from state “A” to state “B”
    - “A” is some problem, need, with constraints
    - “B” is one of many possible solutions
- Who designs?
  - Engineers, architects, authors, musicians, choreographers, chefs…
  - All of us (much of the time)

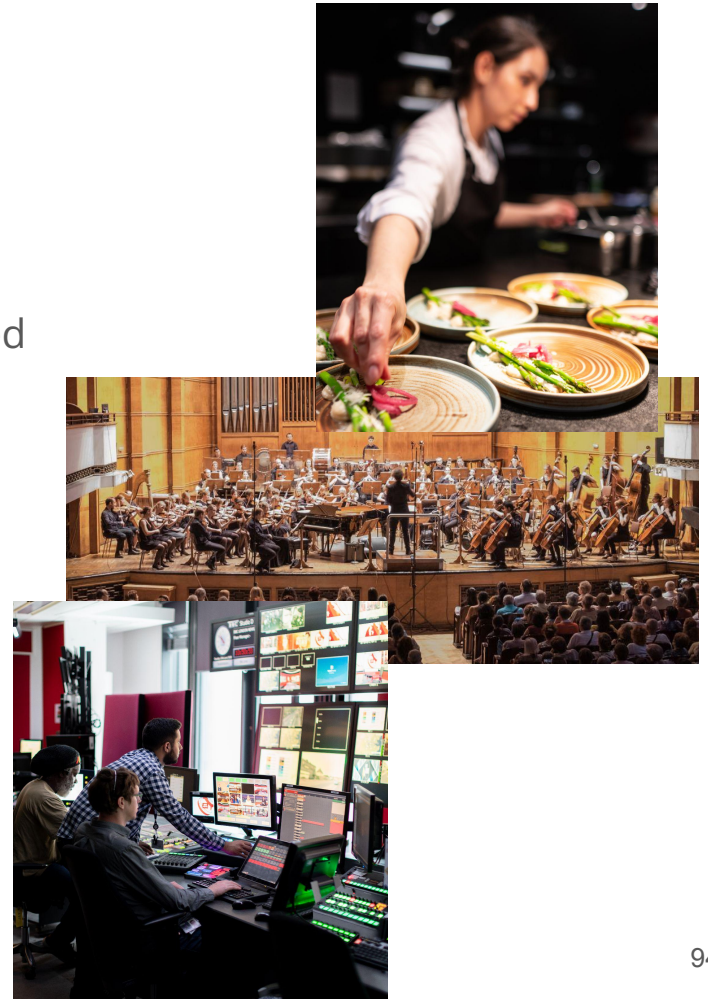


Photo by John Fornander, Manuel Nägeli, ThisisEngineering RAEng on Unsplash

Design: Engaging in design thinking

- Enacting a process
  - Understand the problem (empathize, gather information, define)
  - Generate ideas to solve the problem (brainstorm, ideate)
  - Try out some of the ideas (model, prototype, test)
  - Choose an idea & make it happen (decide, implement, produce)
  - Determine how it worked (assess, reflect, repeat)

- Enacting a process with a nimble, broadly scoped mindset
  - Flexible (converge/diverge; analysis/synthesis; problem/solution)
  - Reflective and engaging in “design awareness”
  - Seeing through the full cycle (identifying need through implementation)
  - Human centered (all stakeholders)
  - Taking a broad perspective and understanding context

Learning research principles I use in my teaching

- Learners come to a situation with a full life already
  - (prior conceptions matter; pathways matter)
- Knowledge organization and integration are important
  - (both concepts and links matter in neural networks)
- Learning happens in the learner, not the teacher
  - (motivation matters; learning is personal)
- Learners should be active not passive
  - (practice retrieval and application)
  - (neurons that fire together, wire together)
- Goal for “transfer” - apply knowledge or skill in new context
  - (invite students to think forward)
- Thinking about thinking is important
  - (reflection and metacognition matter)

1) Bransford, J. D., Brown, A. L., & Cocking, R. R. (2000). *How people learn* (Vol. 11). Washington, DC: National academy press; 2) Ambrose, S. A., Bridges, M. W., DiPietro, M., Lovett, M. C., & Norman, M. K. (2010). *How learning works: Seven research-based principles for smart teaching*. John Wiley & Sons.; 3) Felder, R. M., & Brent, R. (2016). *Teaching and learning STEM: A practical guide*. John Wiley & Sons.; 4) National Academies of Sciences, Engineering, and Medicine. (2018). *How people learn II: Learners, contexts, and cultures*. National Academies Press.

Developed a set of design teaching activities based on learning research

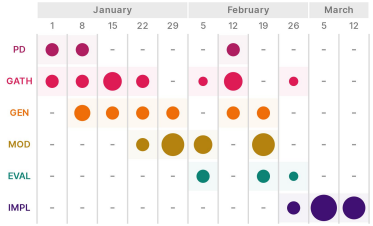
- Honor students' past experiences as designers
- Invite a "lived experience" through active participation ("re-concretize" the abstract models)
- Actively help students make links across concepts to build neural networks
- Are exciting to engage with (and hence motivational)
- Invite students to think forward to themselves as future designers
- Make space for students to be reflective about their design processes

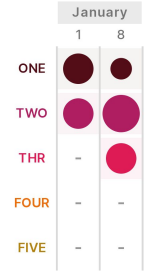
Problem Statement: Design a Playground

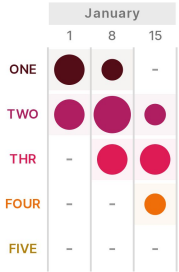
- Subject to a set of constraints
  - most of the children who will use the playground will range from **1 to 10** years of age.
  - **Twelve children** should be kept busy at any one time.
  - There should be at least **three different types of activities** for the children.
  - Must be **safe** for the children,
  - Must **remain outside** all year long,
  - Must **not cost too much,**
  - Must comply with the **Americans with Disabilities Act.**
- Your design should use materials that are available at any hardware or lumber store.
- The playground must be ready for use in 2 months.

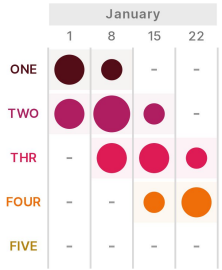
Asynchronous tracking: some possibilities

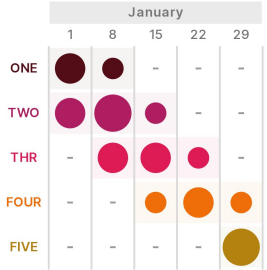
- Possible uses
  - Create boundary objects to show patterns of design behaviours across time
  - Student reflection on their processes
  - Students in teams compare their timelines to promote conversation
  - Help students tell the story of themselves as designers











Asking a broader community: Good designers do “X”

Good Designers do “X”: Cindy’s response

- **Consider context and consequences**
- **Include many perspectives**
- **Scope, gather, model, iterate, cascade**
- **Ask questions**
- **Enact design awareness**
- **Understand that design embodies values**

Good Designers do “X”

- Janet McDonnell, Emeritus, Central Saint Martins, London
  - Seek and engage in authentic collaboration
  - Attend to the ethics of their professional actions
  - Interrogate the brief, i.e. the characterisation of the 'task' or the construct of the 'problem'
  - Move fluidly between generating and critically evaluating proposals as design progresses
- Sheri Sheppard, Stanford University
  - Ask a lot of questions of people obviously and not obviously “stakeholder” and/or knowledgeable about the situation. (and the questions get beyond the surface)
  - Connect ideas and concepts not obviously connected
  - Do not fall in love with their own ideas.
  - Use a variety of approaches for feedback and engagement
  - Are continuous and curious learners about the world
  - Question how/where/if design is the appropriate tool for the situation at hand
- Jennifer Turns, University of Washington
  - Have a learning orientation—they collect lots of information by asking questions
  - Ideate not just solutions but also ways of defining the problem, ways of configuring the design process
  - Are oriented toward action. Seeking to not get stuck; to keep the process moving along
  - Find ways to try out (aka prototype) their ideas as soon as possible and continually with a goal of getting information that will make it possible to iterate
  - Make design social
  - Don’t just "have" an idea; they also talk about and through their idea a lot. They spend time explaining it, narrating it, representing it, etc.

Affinity group titles - Wednesday Dear Design seminar

Ask questions
Attitude
Awareness
Beyond design
Build prototypes
Consider stakeholders and Team dynamics
Decision making
Design is personal
Design thinking processes
Frameworks + constraints and Process driven
Future thinking
Growth / learning
Impact
Inclusivity and diversity
Iterations
Less is more
Problem definition
Resourceful
See design everywhere
Self-evaluation
Understanding of complexity / systems approach
Values and ethics

Affinity group titles - Thursday Dear Design seminar

Action-oriented

Attitude

Build relationships with stakeholders

Communication

Constraint mindset

Creativity

Critical

Design decision

Design process

Design thinking

Designing with intention

Empathy and compassion

Ethics

Forward thinking

Inter/multidisciplinary considerations and mindset

Learning

Prioritize

Questioning

Research / Scoping

Self-awareness / reflection

Simplifying

Work broadly

Good Designers do “X”: Student reflections

“I found it really interesting about designing with the intent to make the world better equitably and socially, but also understanding that even the smallest moments can have a big impact too.”

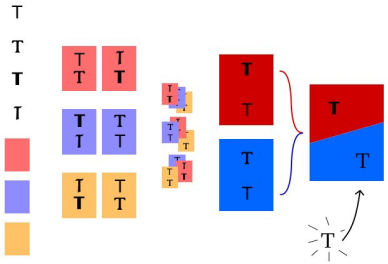
Seminar design principles

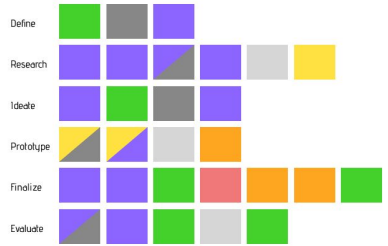
- Postcard format: creative, abstract concepts made concrete
  (motivation matters, knowledge networks)
- Looking back, looking forward
  (honor prior conceptions, transfer)
- Rhythm of repetition: do design, synthesize, create representation, share out
  (active learning, knowledge networks, goal-directed practice, transfer)
- Sharing postcards, learning from others
  (learning is a social endeavor)
- Reflection/Focus on process
  (metacognition, self-directed learner)
- Deeply personal, design identity development, story of self as designer
  (motivation matters, time on task, self-directed learner)

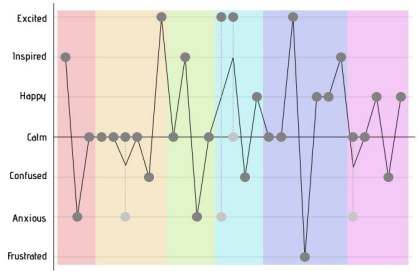
Bransford, J. D., Brown, A. L., & Cocking, R. R. (2000). *How people learn* (Vol. 11). Washington, DC: National academy press. Ambrose, S. A., Bridges, M. W., DiPietro, M., Lovett, M. C., & Norman, M. K. (2010). *How learning works: Seven research-based principles for smart teaching*. John Wiley & Sons.; National Academies of Sciences, Engineering, and Medicine. (2018). *How people learn II: Learners, contexts, and cultures.* National Academies Press.

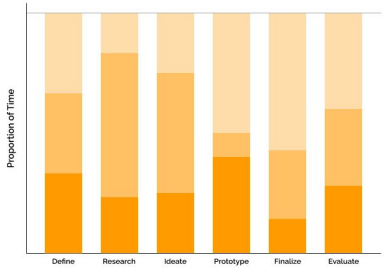
Dear Data across the 9 weeks

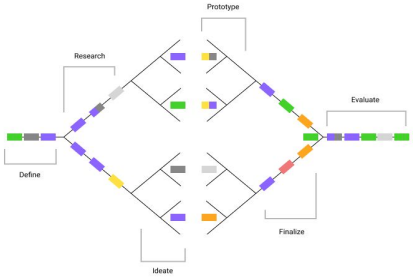
Eileen Zhang

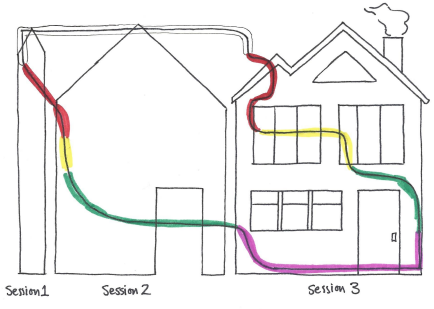


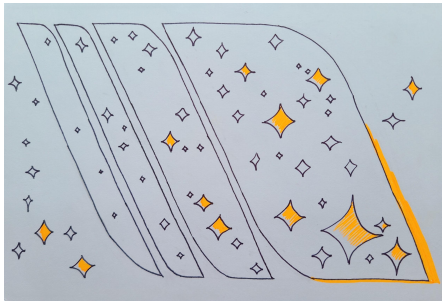












Dear Design: Impact

Dear Design: Design Awareness Questions

TIME

- **How do I distribute my time in my design processes?**
- What areas should I spend more time on?
- How much time do I spend thinking vs doing?
- How often do I take a break during my design process and what do I do/feel during these times?
- Which stage of my process am I most distracted?
- How much time do I spend in collaborating with others?
- How often do I diverge and converge through my design process?

CHALLENGES

- **How do I deal with roadblocks/challenges?**
- At what points do I experience idle/creative blocks and "aha" moments?

STAKEHOLDERS & USER NEEDS

- **When do I need to integrate external stakeholders in my process?**
- Who are the stakeholders? How do I involve them more in my design process?

INTENTIONALITY

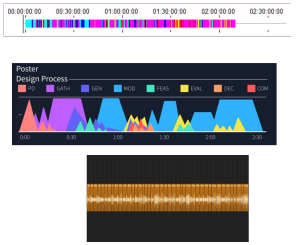
- **What aspects of my design process can I be more intentional about?**
- What prevents me from being mindful or more intentional about certain aspects of my process and how can I address that?
- How intentional am I about iteration? What differences show up when I don't iterate

EMOTION & MOTIVATION

- How do my motivation and enthusiasm levels change and correlate throughout my design process?
- When am I feeling the most positive or negative? As I diverge / converge on design ideas, are there any visible emotion patterns?
- **Which stages of the design process do I enjoy most (e.g. research, prototyping, UI)?**

Leaning into ambiguity…design awareness

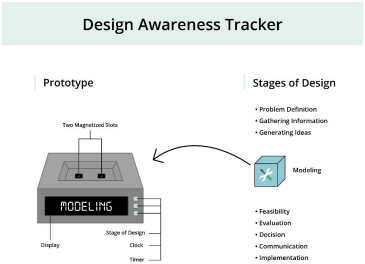
- A decade of focus on large centers (CELT, CAEE, CPREE)
- Design work: many slices, not in focus yet
  - Moving from “knowing about” to “enacting while doing”
    - Classroom presentations not enough
  - Student’s recording own design processes (McDonnell & Molhave)
  - Reflection in engineering education (Jennifer Turns, CPREE)
- Goal: reflective designers aware of their process
  - Reflection-in-action/reflection-on-action (Schon)
- Leaning into ambiguity
  - Conversations about mindfulness and awareness, and the enthusiasm of some amazing students led to..
  - The “design awareness” seminar

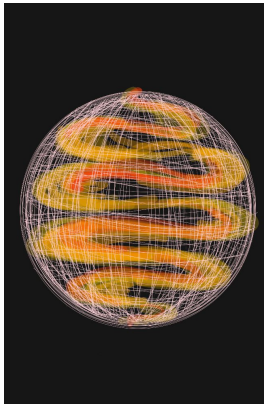


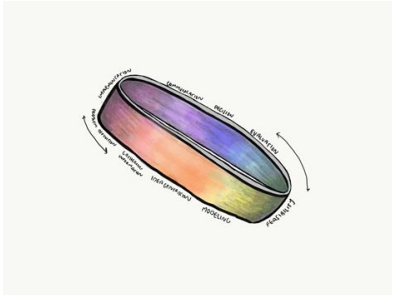
(Mølhave, McDonnell, & Atman, 2011; McDonnell & Atman, 2015; Schon, D. A. (1968). The reflective practitioner. *New York*.)

Design Awareness Seminar

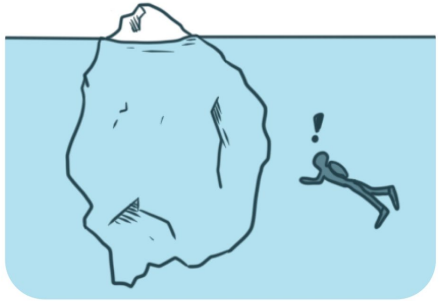
- Aaron Joya, Grace Barar, Alison Gray, Khadijah Jordan, Rylie Sweem, Nicole Washington
- Design awareness seminar
  - Tracing past & present design processes
  - Explore timeline research and design models
  - Define design awareness
  - Ideate design awareness tool
- Led to creating an app







Describing Design Awareness



“Seeing the rest of the iceberg”
~Khadijah Jordan

“Staying cognizant of your design process in order to make more [intentional] decisions about what to do next…”
~ Khadijah Jordan

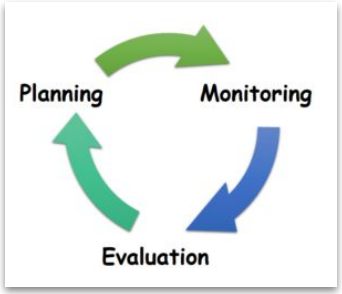
“Knowing where you have been, where you are, and where you are going”
~ Nicole Washington

Design Awareness

Someone with keen *Design Awareness* is able to:

- understand the design process in general,
- understand and plan their own design processes (plan),
- stay aware of where they are in a design process (monitor),
- engage in reflection-in-action to compare their current process with the process they planned (monitor),
- Make informed decision about their next design activity,
- enact those choices, and then
- reflect and continue the cycle (evaluate/reflect)…

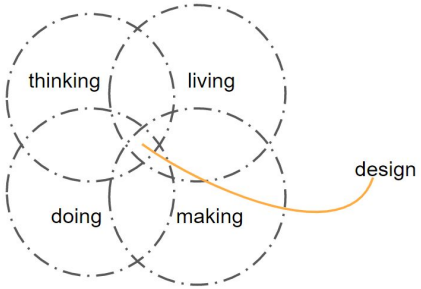
Metacognition - Plan/Monitor/Evaluate

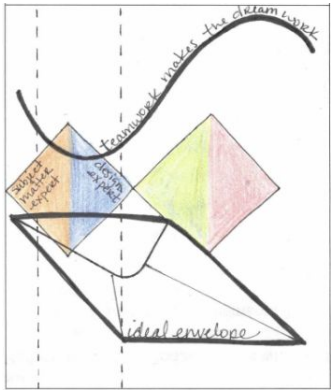


Regulatory Metacognitive Skills (Kluwe, 1987; Schraw & Moshman, 1995; Schraw, 1998; Pintrich, 2002, 2004; Zimmerman & Campillo, 2003; Zimmerman, 2011)

Recap - Two

- Three activities
  - What counts as design?
  - Many models of design
  - What are expert design behaviours?





Casey Kelly

- Help students to
  - **See themselves as designers** in their everyday lives (this can help them see themselves as engineering designers)
  - Understand that there are **many models of design** and they can choose models that help in different circumstances
  - Appreciate that **expert designers engage in a set of behaviours** that they can learn, practice and reflect upon
  - Develop **resilience** and **confidence** in themselves as reflective designers with a **nimble mindset**

Nigel Cross on Transdisciplinary Design

From origins in professional design practice, design thinking has developed to embody ways of working for the creative resolution of issues in a variety of situations. Initially seen as forming foundations for a science of design, research into how designers think and work came to establish the discipline of design, based around understanding and explicating the implicit processes of designerly ways of knowing, acting and thinking. These implicit or 'intuitive' processes have been found to constitute effective competencies for dealing with unique, complex, value-laden, complex situations. Some of these design thinking processes became widely promoted and adopted outside professional design practice, for pursuing innovation within business, industry, technology and society. From these developments of design thinking there is now emerging a transdisciplinary approach towards a way of thinking and working that embodies a form of strategic, adaptive, co-operative design intelligence for engaging creatively with problematic situations.

Contribution to forthcoming *Encyclopedia of Interdisciplinarity and Transdisciplinarity,* Frédéric Darbellay (ed.), Edward Elgar Publishing.

Affordances of “signatures”

- Personal
- Vary across people
- Vary based on context
- Can change over time
- Are under your control