

# My story...

## Engineering Education Coalitions (ECSEL – 1991-2001)

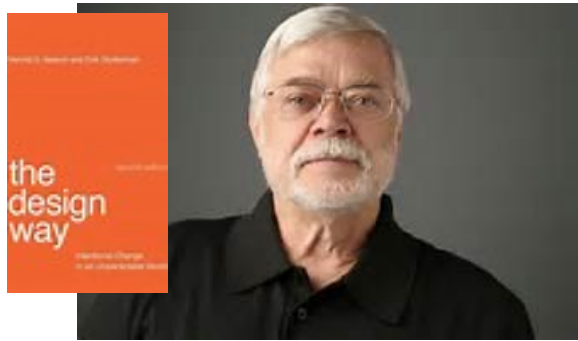
- Pre-service teachers take freshman design + debrief and connect course
- Teacher workshops (bring design into K-12)
- Building capacity in engineering education research

## Research on design / cross-disciplinary knowing, doing, being (ongoing)

- Shared dataset – design reviews (Design Research Society – DTRS 10)
- Undergraduate and graduate level design education
- Research in professional settings (breakthrough thinking) + mentoring

## P-12 integrated STEM (current projects)

- NSF CORE Energy 3D (Charles Xie (Concord Consortium), Senay Purzer (Purdue))
- NSF EngrTeams (Tamara Moore, PI with Selcen Guzey, Kerrie Douglas)
- NSF IUSE UPDATE integrated elementary education program (Brenda Capobianco, PI with David Eichenger, Sanjay Noble, Minjung Ryu, Selcen Guzey, Kendra Erk)



Harrold Nelson and Eric Stolterman

# *What is the “Design Way”:* **Iterative intention-judgment cycles**

The process of design is the path of human **intentions** being pursued by the designer or user of design through the **stages of exploration, composition, judgment and action**.

The stages are **iterative** and the designer revisits the previous stages to **develop conviction and build support for the next move forward** towards the articulation of the design form and structure.

The process of design does not end here with the action that realizes a product, service or change in the environment. It is still in need of **active support from the stake-holders and in need of promotion and nurturing if it is to succeed and become sustainable**.

Design, unlike science and technology, is not about finding a fundamental truth or about finding what is possible with a material, situation or context. It is about the **realization of our intentions in a desirable manner** that can give us a better future, even if the future that we seek is unknowable.

# Confessions of a “design” broker in P-12

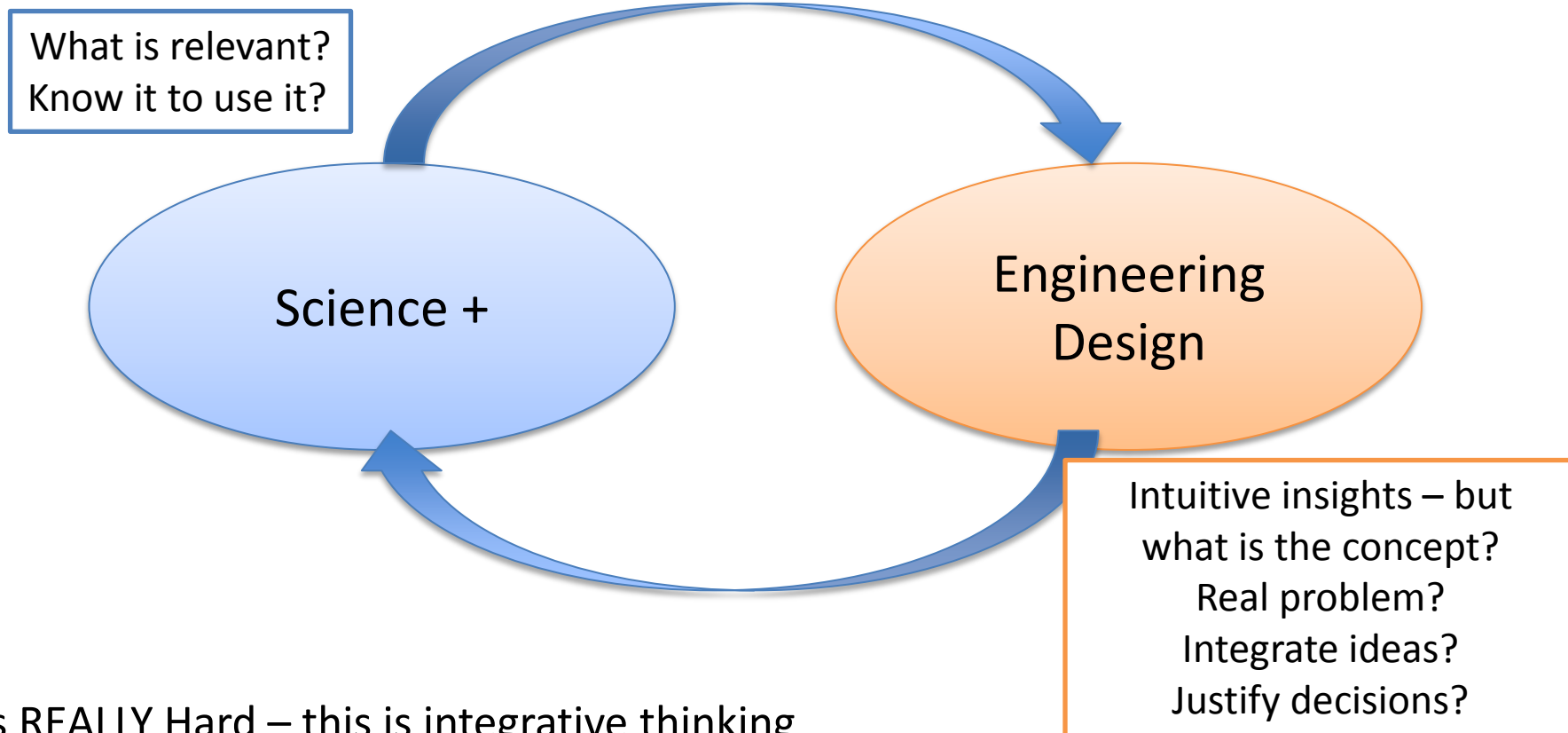
- Translator and broker – a user-centered perspective
  - What are they trying to do – how illuminate the design thinking and knowing?
  - Look for places to leverage integration in current plan – help make it explicit, enhance it
  - Facilitate meaningful borrowing of design content (what is problem framing, really?)
  - Move “integration” story from design as a vehicle for learning to “two-stream” learning
- Communicating design teaching and learning
  - Reframe as “inquiry” – embrace what design as a pedagogy really means
  - Unpack design process – how it embodies design knowledge (more than list of steps)
  - Informed designing – ways to talk about learning progressions you want to see in students
  - Design reviews as critical places for teaching and learning
- Current work
  - Design PCK – making it explicit and shareable (DTRS 10)
  - Design assessments – conceptions of design, self-assessments of informed designing

# Understanding teachers

Struggle with paradox → how to enable the “both/and”?

- Flexibility **vs.** constrained (also “authenticity” vs. “lab experiment”)
- Simplify content **vs.** embrace ambiguity and complexity
- Emphasize aspects of process **vs.** go through whole process
- Accountability to science content **vs.** accountability to design
- Integration as structure / pedagogy **vs.** integration as learning goal
- Teach science then apply via design **vs.** . do design as start point for teaching science
  - They both work...and have benefits...there isn't a “right way”
- “The” model of design **vs.** many models of design

# Taking a step back – Integration is really difficult



This is REALLY Hard – this is integrative thinking

- Being “agile” with the science – knowing what is relevant AND knowing it well enough to apply it accurately to a situation
- Being “agile” with knowing design – strategies for how to start, move forward, stop
- Oh...these are NOT the only things being integrated...(as we heard from the stories)

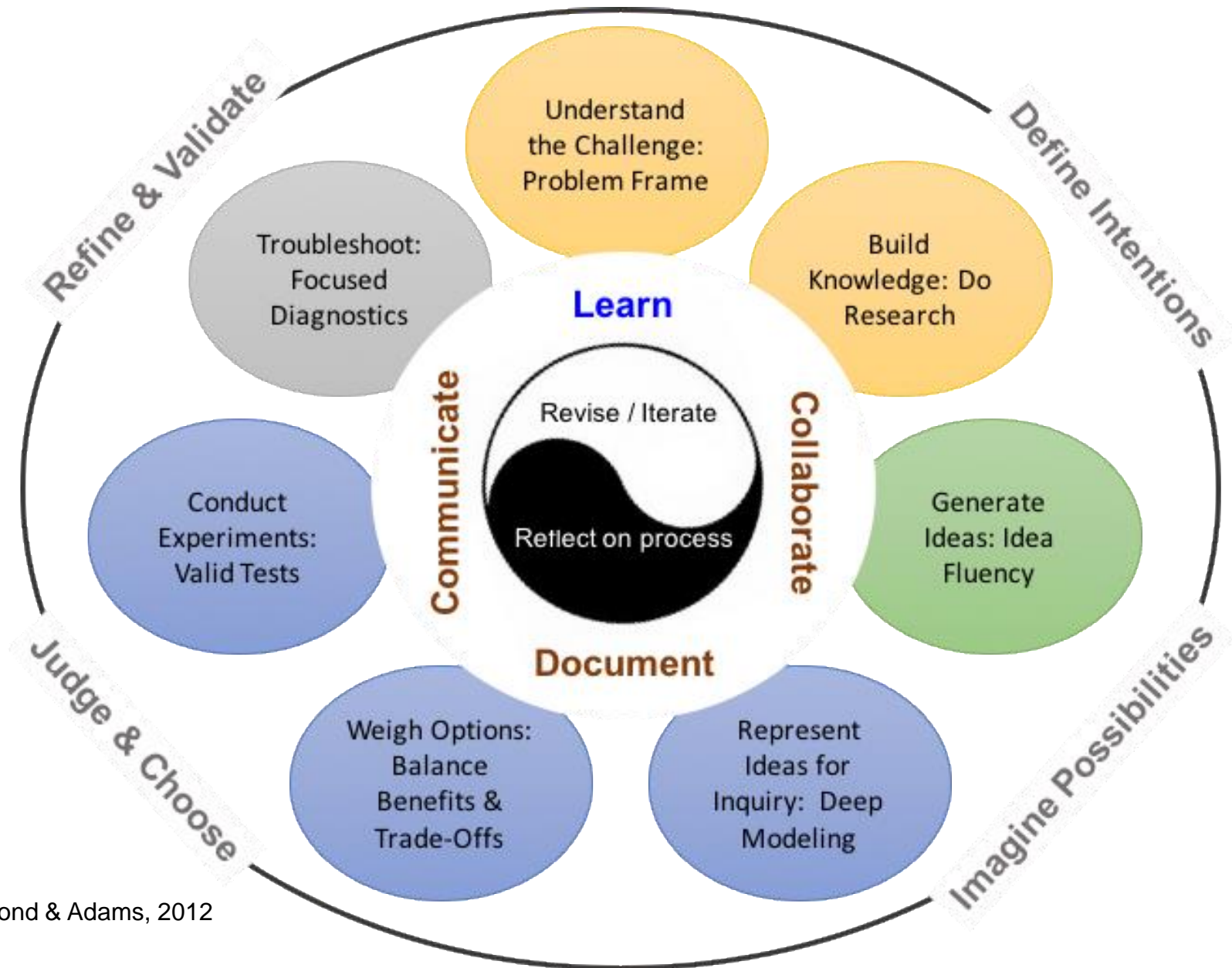
# Working with teachers

- What the “translator story” looks like in action with teachers
  - Talk through their curriculum – ask questions
  - Talk through design goals – ask priorities
  - Listen...make connections (strengthen links, enable borrowing)
  - Share (my PCK) stories of where students may struggle
  - Offer feedback
  - Iterative process...

# So, how do I teach design?

- Less about features of the task, more about debriefs → emphasis on learning design
  - Typically – strong emphasis on problem framing and iteration (critical for my students)
  - Have them discuss and explain benefits & risks of informed designing
  - Push to externalize thinking – whiteboard, artifacts, prototypes, design reviews, storyboards...
  - Self-assessments of demonstrating informed design
  - Representing their own design process (vs. model provided) – get it in their own words
  - Relatively consistent messaging: nature of design tasks → requires design strategies used in a relatively consistent sequence but iterative, as needed
- Often sequence as increasing ambiguity or complexity
  - Ease into frustration with “what is right answer?”
  - Threshold concepts – problem definition and iteration
  - May purposefully go “out of steps of process” to emphasize “steps” are really strategies
- I also include integrative thinking – and techniques
- Leverage multiple design reviews – walking through work-in-progress
  - One-on-one, groups, peers, external experts or stakeholders
  - Explain, predict, justify...anticipate and plan

# Methodology: *Informed Designing*





# Informed Designing as Tool → Guide for noticing and intervening

## Content knowledge of design AND self-assessment tool for students

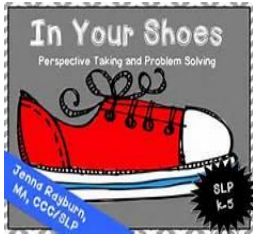
Crismond & Adams (2012)

Design Strategy	Beginning designers...	Informed designers...
<b>Understand the challenge</b>	<b>Problem solve:</b> Treat design task as well-defined, straightforward problem that they prematurely attempt to solve	<b>Problem frame:</b> Delay making design decisions in order to explore, comprehend and frame the problem
<b>Build knowledge</b>	<b>Skip research:</b> Skip doing research and instead pose or build solutions immediately	<b>Do research:</b> Do investigations and research to learn about the problem, how system works, relevant cases, prior solutions
<b>Generate ideas</b>	<b>Idea scarcity:</b> Work with few or just one idea, which they can get fixated on and not want to change or discard	<b>Idea fluency:</b> Practice idea fluency in order to work with lots of ideas by doing divergent thinking, brainstorming, etc.
<b>Represent ideas</b>	<b>Surface modeling:</b> Propose superficial ideas that do not support deep inquiry into a system and that would not work if built	<b>Deep drawing &amp; modeling:</b> Use multiple representations to explore and investigate design ideas and support deeper inquiry into how system works.
<b>Weigh options and make decisions</b>	<b>Ignore benefits and trade-offs:</b> Make design decisions without weighing options or attend only to pros of favored ideas, and cons of lesser approaches	<b>Balance benefits and trade-offs:</b> Use words and graphics to display and weigh both benefits and trade-offs of all ideas before picking a design.
<b>Conduct experiments</b>	<b>Confounded experiments:</b> Do few or no tests on prototypes, or run confounded tests by changing multiple variables in a single experiment	<b>Valid tests and experiments:</b> Conduct valid experiments to learn about materials, key design variables, and how the system works
<b>Troubleshoot</b>	<b>Unfocused troubleshooting:</b> Use an unfocused, non-analytical way to view prototypes during testing and troubleshooting of ideas	<b>Diagnostic troubleshooting:</b> Focus attention on problematic areas and subsystems when troubleshooting devices and proposing ways to fix them
<b>Revise/Iterate</b>	<b>Haphazard or linear designing:</b> Design in haphazard ways where little learning gets done, or do design steps once in linear order	<b>Managed and iterative designing:</b> Do design in a managed way, where ideas are improved iteratively via feedback, and strategies are used multiple times as needed, in any order
<b>Reflect on process</b>	<b>Tacit design thinking:</b> Do tacit designing with little self-monitoring while working or reflecting on the process and product when done	<b>Reflective design thinking:</b> Practice reflective thinking by keeping tabs on design strategies and thinking while working and after finished



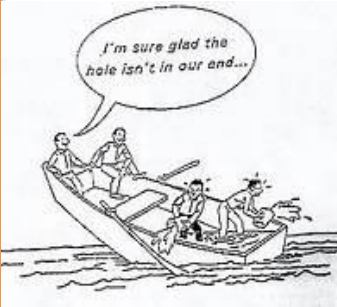
### Integrative thinking

Ability to knit together information from different sources to produce a more comprehensive understanding or create new meaning.



### Perspective taking

Capacity to view a problem or artifact from alternative viewpoints, in order to develop a more comprehensive understanding of it.



### Systems thinking

Ability to break a problem down into its constituent parts to reveal internal and external factors, figure out how each part relates to the others and to the problem as a whole, and identify which parts different perspectives address.

### Contextual thinking

Ability to view a subject from a broad perspective by placing it in the fabric of time, culture, or personal experience.



### Critical thinking

The capacity to analyze, critique and assess: ideas about knowledge and knowing, arguments you find convincing