

A thesis on “How might students wonder and play their way into deep learning?”

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Wonder, Play, Learn:

How might students wonder and play their way into deep learning

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Abstract:

How might we encourage students to “wonder” and “play” their way into deep learning?

It is within the context of design education that I explore this question. Design students are expected to develop expertise in designing for wicked problems and long time horizon futures. This requires efficiencies with understanding and navigating complex systems, drawing productively upon vast information resources, agile prototyping skills and evaluative methods, and resilience in a highly iterative, low-signal feedback environment. While experts thrive within the complexity of systems-level thinking, novices tend to become overwhelmed, looking to the experts for direction. Experts’ knowledge and processes tend to be tacit leaving novices floundering for productive courses of action. This thesis explores a framework for wonder (wonder as experience, interaction, action, sustained action) as a means to bridge this gap.

Through this study of wonder, differences in organization of knowledge between experts and novices, aspects of motivation in game and learning environments, fly-on-the-wall observations in a design studio classroom, and two sample participatory and user studies with masters and undergraduate students, this thesis puts forth that wonder provides a framework for: a.) unpacking expert processes thereby making these explicit/accessible to novices; b.) designing student-centered learning with flexible scaffolding to address students’ motivational ebbs and flows as they develop expertise; c.) increasing agency by triggering the novice’s capacity for wonder and extending that through a frame that focuses attention and directs and sustains effort.

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Let's have a hootenanny!

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Introduction: How might students wonder and play their way into deep learning?

Overview

Increasingly, design students are being asked to solve wicked problems¹ with long time horizons (e.g. sustainability, healthcare, education). This is evidenced by the School of Design’s 2014 curriculum revision aimed at addressing “the changing role of design in the 21st century.” Two of the three foci, social innovation and transition design, reposition the designer towards this new reality. Experts have strategies for navigating and thriving within this context of systems within systems-level problems and thinking, but novices tend to struggle and become overwhelmed by the complexity. Why are experts so agile working within this context? Experts have rich knowledge networks and robust processes they leverage to operate efficiently and effectively, whereas novices don’t. Novices have to rely on sheer grit and motivation as they build up expertise and experience. Getting students up to speed quickly with the new methods and robust design processes is challenging. **Wonder can help.**

What’s the context?

Changing field of design impacting the way designers are expected to think and work

“As corporations, governmental organizations, and civil associations face accelerating change in uncertain times, increasingly they are looking to designers for new ways of thinking and acting. Designers today are engaged as thought leaders, strategists, activists, and agents of change in complex socio-technical problems throughout private, public, civil and philanthropic sectors worldwide. For designers trained to shape futures defined by uncertainty and change, these exponential times represent unprecedented creative opportunities for innovation.”

– Arnold Wasserman, Peter Scupelli, *Dexign the Future*, 2013

As Wasserman and Scupelli indicate, designers are working on new kinds of problems in a highly dynamic context and new methods and finely tuned processes are necessary to adapt to and operate effectively in these new situations. What’s hard about change is that the novice doesn’t know where to begin and becomes easily overwhelmed, essentially “submerging the individual’s perceptual, conceptual, and active powers, subduing his capacity” (as Parson’s describes in *A Philosophy of Wonder*). Experts, on the other hand, have great capacity for filtering information in relevant and productive ways and find the dynamic context highly motivating.

¹ Wicked problems: Rittel and Webber described “wicked problems” as having 10 defining characteristics:

1. There is no definitive formulation of a wicked problem.
2. Wicked problems have no stopping rule.
3. Solutions to wicked problems are not true-or-false, but good-or-bad.
4. There is no immediate and no ultimate test of a solution to a wicked problem.
5. Every solution to a wicked problem is a "one-shot operation"; because there is no opportunity to learn by trial-and-error, every attempt counts significantly.
6. Wicked problems do not have an enumerable (or an exhaustively describable) set of potential solutions, nor is there a well-described set of permissible operations that may be incorporated into the plan.
7. Every wicked problem is essentially unique.
8. Every wicked problem can be considered to be a symptom of another problem.
9. The existence of a discrepancy representing a wicked problem can be explained in numerous ways. The choice of explanation determines the nature of the problem's resolution.
10. The planner has no right to be wrong (They are liable for the consequences of their actions).

What’s the problem?

There’s gap between what experts and novices think and do

When design students are trying to find the problem and the opportunity that’s worth working on, I’ve observed that they appear to resist self-driven exploration, they tend to look primarily to the instructor “the expert” for “the answer”, and dwell for long periods at the superficial level of design exploration. For example, in the *Dexign the Future* (DTF) class, one instructor responded to students’ questions in this way:

“You should take the initiative. There’s a question there that requires reflection. Don’t leave it up to us. Your ideas are much more important to the content of the course than ours. How you use the information we push is up to you.”

What is it that might explain this gap between expert and novice practice?

Experts know how to wonder in a way that leads them to design action. Novices don’t.

In *Initial mental representations of design problems: Differences between experts and novices*, Bjorklund describes expert practice: for experts there is not one representation of the problem, but rather a co-evolving and dynamic process of actively pursuing information to facilitate one’s ability to dynamically structure (form a representation of) the problem and evaluate solutions early and often in the process; and iterate on both problem representation and solution ideation and evaluation.

“Designers must interpret the input they receive or collect regarding a design project in order to create a first representation of the problem at hand (Visser, 2006). ...Unlike novices, experts question data, are aware of limitations and relationships between issues, and differentiate between important and less important issues (Ahmed et al., 2003).” (Bjorklund, pg 151, 138)

When experts receive a design brief, they reframe it to create a fruitful and actionable view of the project, whereas design novices may pay more attention to the superficial features (e.g. the form of communication and presentation of the brief) (Bjorklund, pg 137,138). Experts also have rich knowledge networks and past experiences to draw upon when working on design problems. As a result, they are able to spot patterns that help them to efficiently navigate the complexities of the problem space and target relevant actions to take. (Bjorklund, pg 137)

“In addition to evaluating the available information, design experts also tend to evaluate the solution more and earlier than novices (Ahmed et al., 2003; Ball, Evans, Dennis, & Ormerod, 1997), and engage in more reflection in general (Crakett, 2004; Petre, 2004; Schon, 1983). ...The problem representation develops hand in hand with the solution and the ‘information needed to understand the problem depends upon one’s idea for solving it.’ ” (Bjorklund, pg138, 139)

These expert processes require an interrogative core.

Figures 1 and 2 contrast differences between expert and novice design processes. The expert’s process is much more robust. S/he brings to bear a lot of prior experience and uses an iterative and inquiry-driven approach to design (i.e., the expert wonders concretely). By contrast, the novice depends largely on external expertise and new information sources; s/he tends not to question the data at hand or iterate and evaluate early and often.

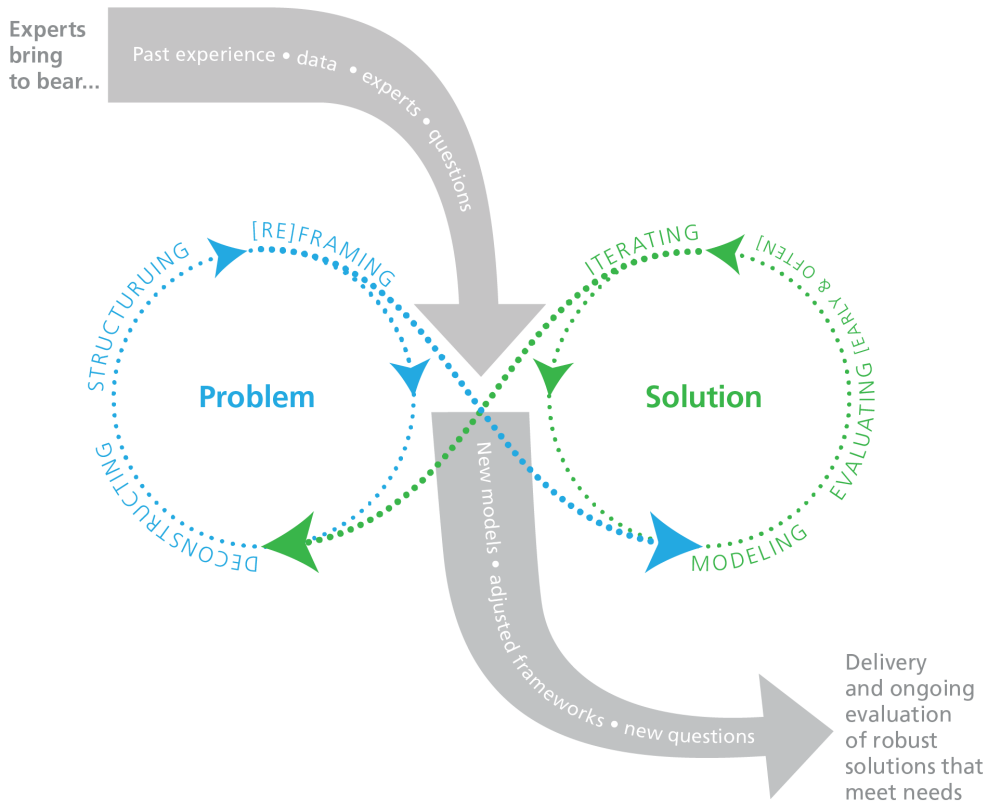


Figure 1: The expert’s process is self-driven, dynamic, detail- and action-oriented, highly integrative and recursive whereby **the problem and solution are co-evolving**. The outputs of the expert’s practice are robust with new models, frameworks, and questions emerging in addition to solutions that meet needs. By contrast, Figure 2 (below) illustrates the novice’s process as less integrative and robust.

Novices bring to bear...

No to little past experience and superficial perspectives on the design brief

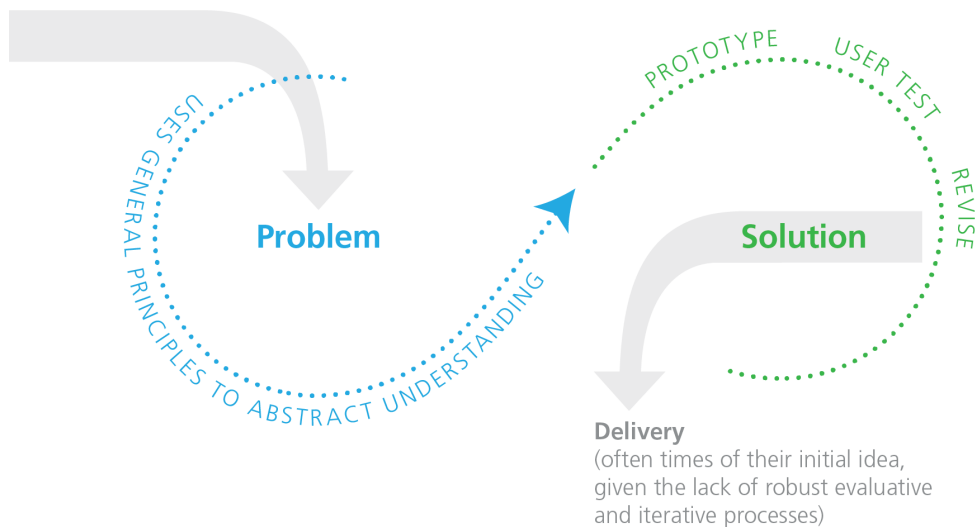


Figure 2: The novice’s process is broken into more discrete phases. S/he tends to focus on superficial features of the design brief; tends to represent the problem without interrogating the data at hand; then moves on to prototyping a solution without evaluating early and often in the process.

Novices tend to think in discrete sequential chunks. The novice relies heavily on “canonical” sources of information (the design brief) about the problem, the users, their needs, constraints of the project, requirements, etc. And the novice thinks in terms of problems and solutions. What tends to be missing from their process is the deliberate interrogation of the information at hand that guides further action and the persistent iterative nature of the expert’s practice.

FROM ANSWERS TO QUESTIONS

For the first half of my life as a designer I thought about design as a series of problems to be solved. For the second half I thought about design as interesting questions to be asked. The shift did not necessarily make my design work more brilliant. But the shift from problems to questions certainly made my life more interesting. It led me onto paths I would never have encountered otherwise – like doing 6 startups (3 hits, 2 misses, 1 draw). It made my life international. It led me to work on projects along the complete spectrum of design fields... If you think of this course as a problem to solve you probably won’t get a lot out of it. Think of it rather as an exploration for interesting questions to ask. – *Arnold Wasserman*

Expert’s recursively question and actively pursue the knowledge they need



Figure 3: Experts implicitly question throughout the process (e.g., “What do I know I don’t know?”), which in turn sets them on a deliberate and focused course of action.

Building on what Bjorklund points out about expert and novice processes, Ambrose, et. al. relate this same topic to teaching and learning. Experts have strong knowledge networks in place for sense making; they have a lot of methods and processes and know how to filter information using implicit metacognitive processes. In terms of teaching, this lends itself to making their knowledge and expertise tacit, not explicit or *easily* transferrable, as their “expert’s blind spot” makes it difficult to see components of the process novices need to practice and to articulate those at novice’s level of understanding (Ambrose, et. al.). (Figure 4)

Novices, on the other hand, have weaker networks, are working from their own prior knowledge (sometimes appropriately, relevantly, sometimes not so) and have difficulty making connections. Furthermore, novices tend not to be aware of their own metacognitive processes. (Figure 5)

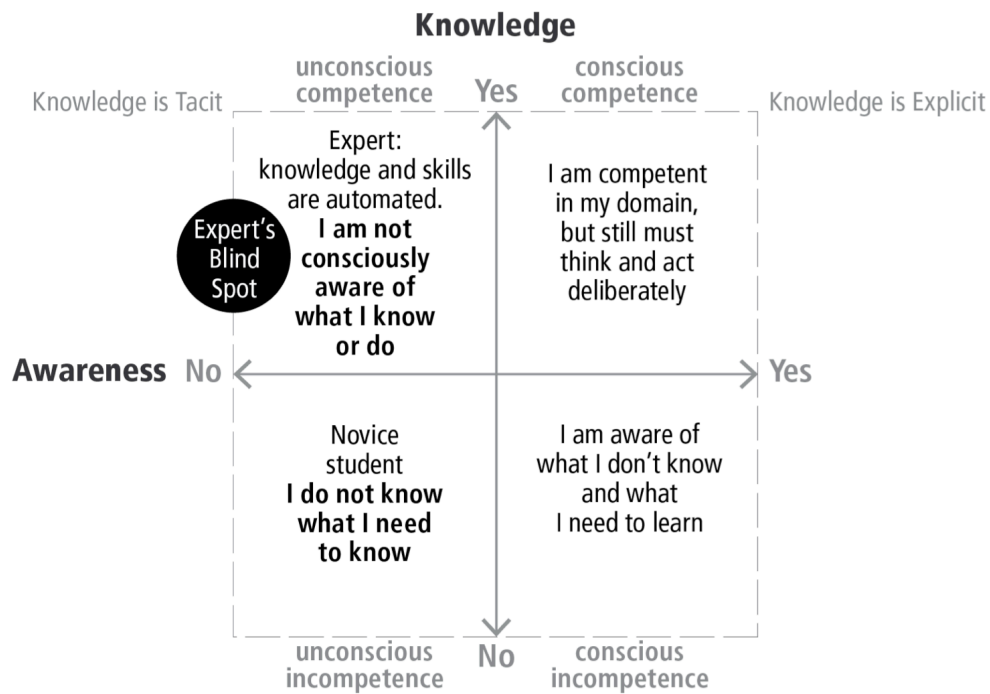


Figure 4: To reveal “expert’s blind spot” we compare two dimensions: degree of knowledge and awareness of knowledge. We see that expert’s blind spot shows up when competence has become so integral that the knowledge is tacit. Novices, on the other hand, range from having complete lack of awareness about what they don’t know to deliberately thinking and acting/effortfully applying what they know. (Adapted from Ambrose, et. al., page 97)

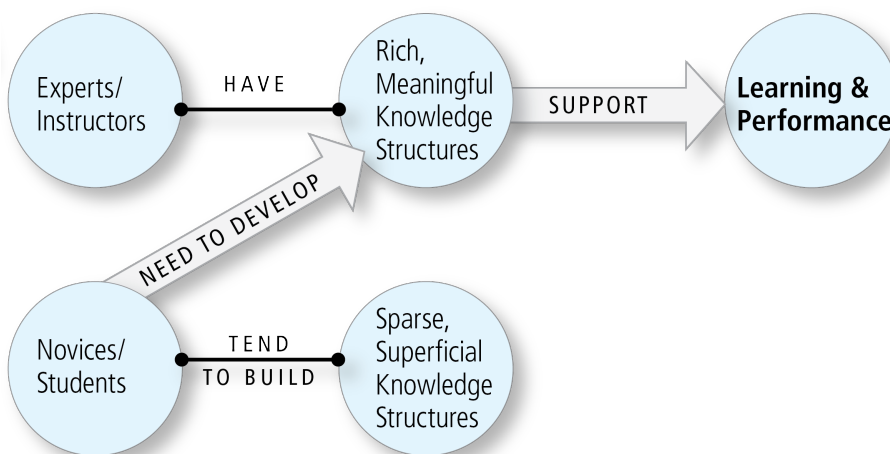


Figure 5: Organization of knowledge: differences between experts and novices. Experts have rich meaningful knowledge structures. Novices tend to “build” sparse, superficial knowledge structures. For learning and performance novices need to develop rich meaningful knowledge structures. (Ambrose, et al)

According to Marsha Lovett, Director, Eberly Center for Teaching Excellence & Educational Innovation at Carnegie Mellon University, sparser knowledge organizations make it hard for students to see connections that are apparent to experts. She and her colleagues address this topic in depth in *How Learning Works*. They point to results from a study conducted by Chi, Feltovich & Glaser (1989) revealing that novices categorized physics problems according to their superficial features (e.g., pulleys, inclines, rotation) whereas experts categorized them by their structural features (e.g., problems involving conservation of energy, problems that utilize Newton’s Second Law). (Figure 6)

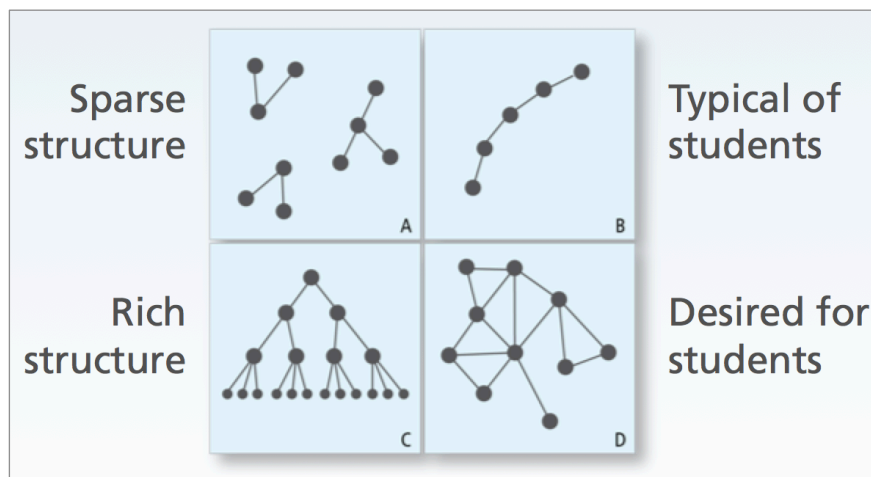


Figure 6: Organization of knowledge: experts have rich structures while students tend to build sparse, superficial structures. “Organization of knowledge is like a mental map: Many roads = easy access. Few roads = limited access.” (Marsha Lovett, Director, Eberly Center for Teaching Excellence & Educational Innovation, Carnegie Mellon University)

Novices have insufficient processes for productively engaging new design methods, complex problems

The intersection of future studies with design studies is an emerging field. One reason is because as people start to look at more complex problems (e.g. sustainability), they are looking at the long-time horizon. While students are being asked to design for this new context, the methods for teaching this are not yet clear as to what will work and what won’t.

In the *Design the Future* (DTF) classroom, we observed what one might describe as gaps in novices’ knowledge structures when after a visit to the CREATE Lab (see pages 25-29), students were unable to engage in a robust classroom discussion or articulate connections between innovative projects occurring in the Lab and implications for long-time horizon desirable futures (e.g. What does this work tell us about weak signals, forces of change? How might the CREATE Lab projects inform your own team projects and the pathways you define for desirable futures?). Most students were able to discuss “what” the projects were and how they felt about them, but were unable to articulate “connections” between that work and their class work (e.g. weak signals, forces of change, pathways).

Given the novice’s sparse and disconnected knowledge state and insufficient design processes, how might we help novices to build rich knowledge structures?

Wonder can play a role by unpacking the expert’s practice and inserting an explicit quest, thus providing novices with an expert model to guide their practice as they work towards mastering new areas of study.

In DTF, traditional human-centered design methods were insufficient for novices envisioning the family of 2050, for mapping weak signals to pathways, and for linking those to future forces of change. Familiar design methods fell short: students were unable to relate “change at the local level” to “global forces of change.” They were unable to make “imaginative leaps” to envision desirable future scenarios. For example, as a semester-long culminating project, student teams needed to produce “future persona scenarios.” Many of these scenarios ended up with only superficial features of a future state. In one future scenario, every aspect of daily life interactions depicted was directly pulled from current day places and routines. The only future-oriented aspect was in how the students labeled the mode of transportation to sound a bit more futuristic.

Another early sign of students’ insufficient design processes was observed when they reported back about their local field observations and interviews. One team reported about their interaction with a local business that rents products to individuals who struggle to own. Students thought they had found a human need and a service that met the need. They did not probe deeper into the nature of the business or the ecosystem that enables the viability of such a business. Rather it was neatly categorized as fitting within the primary focal topic (i.e., sharing) of the team’s investigation.

This type of business is exploiting the consumer by charging them much more money than what the goods are actually worth. Students didn’t question what makes this type of business viable and therefore were unable to contextualize the business and the forces at work. Students were unable to unpack the human need and therefore unable to envision a more desirable future.

What was missing? *Wonder*.

Novices did not question, whereas experts might have asked:

- Is this local business a positive or negative influence on the community?
- Is this something that would be in a desirable future or in a dystopian future?
- What’s the life like of a person who needs/uses such a service?

Why? While students had performed human-centered design methods to identify a need, they failed to acknowledge, articulate, and question current cultural assumptions (e.g., human-centered design is currently operating within the context of the market and profit as the ultimate value). Students did not *question* “value.” Had students articulated and interrogated the idea of “value”, they might have been more able to take an actual imaginative leap into a desirable future scenario (based on real needs, acknowledging future forces of change, identifying pathways forward).

What’s the solution?

Wonder can fill the gap

Wonder could have helped students to draw out the universal values, to see the business for what it was, see the need of the people it “serves”, and to take an imaginative leap towards a desirable future state. With the failure to interrogate the data at hand, students did not/were not able to adequately unpack the need, which had immediate consequences for their ability to envision/take an imaginative leap and create a desirable future scenario.

My interest was peaked; wonder, in its various forms, could fill this gap. It could bring students into an attentive state; provide them with an explicit model to guide their practice with expert thinking and processes; prime them for iterative, evaluative making; and sustain them through uncertain times. I became interested in two research questions: one is about wonder and how might it help novices play their way into deep learning; and the other is, what are the barriers that were keeping novices from wondering?

Summary

As I mentioned, there is a changing landscape for designers who are now brought to the table at the strategic level. In these changing, challenging, and uncertain times, novices struggle with getting up to speed quickly given their sparse networks of knowledge and underdeveloped design processes. I am providing **a framework of wonder** to a.) make more explicit to novices the component skills that experts have and use, so that novices can understand what it is they need to do to work effectively and efficiently on wicked problems; b.) provide novices with practice developing those component skills to support building expertise, as well as to help them be more efficient in building capacity with using new methods; and c.) deliberately develop their metacognitive skills so that they can become more self-directed in the interrogative and iterative nature of design practice. Next, I will take you on an exploration of wonder, play, and learn to help us understand better how these interact to create the conditions for novices to develop expert design processes.

Chapter 1: Exploring Wonder in the Field

Overview

People wonder in many ways. We are recipients of it when we find ourselves awestruck, we experience it when we are curious, and act on it when we question, put ourselves on a quest; and, we recreate it for ourselves to invoke the affect of wonder. In this section, we define wonder and see what it looks like in the field. We will also observe an actual design studio class (DTF) to gain insight about wonder for learning. One might expect to find a lot of wonder happening in a class requiring students to make imaginative leaps into the future.

What is wonder and how does it work?

Definitions

When you look up the word “wonder” in the Oxford English Dictionary, you will find these definitions among others:

wonder, v.

1. *intr.* To feel or be affected with wonder; to be struck with surprise or astonishment, to marvel. Also *occas.* to express wonder in speech.
2. Usually with clause: To ask oneself in wonderment; to feel some doubt or curiosity (how, whether, why, etc.); to be desirous to know or learn.
I wonder is often placed after a question which expresses the object of curiosity or doubt; e.g. ‘How can that be, I wonder?’ = I wonder how that can be. Also **I wonder!** colloq. Exclamation expressing doubt, incredulity, or reserve of judgement.
1858 Punch XXXIV. 2 Well, I'm sure! What next, I wonder!
- †4. To affect or strike with wonder; to cause to marvel, amaze, astound.

Similarly put: “A common type of wonder, the one indicated in the usual English dictionary meaning, is a strong emotional experience containing elements of ideation and disposition to act which are, in the initial stage, suppressed and undeveloped. Wonder in such cases is (1) a feeling of startle or surprise and (2) an incipient, inquisitive interest in the object of wonder (the wonderful).” (Parsons, pg 85)

For the context and purposes of this thesis (i.e. learning), I began to have an impression about how wonder plays a role. I needed however, to find a way to more deeply understand “wonder” – to internalize it, represent it in some form, to frame it for the work I needed to do here.

Experiencing Wonder

And so I began by observing people in a few of the “wondrous” places that we humans have created for ourselves: the National Aviary, Phipps Conservatory, and compared those to similar online venues like nature webcams, where we can peak into and vicariously experience the world of the wild. (Figure 7)



Figure 7: A photographic essay showing my observations of people experiencing wonder at the National Aviary, Phipps Conservatory, and online via nature webcam websites. (See Appendix for enlarged view.)

It became clear to me that designed into these spaces are signals, and in some cases explicit signs, of what we humans value and hence (re)create to experience as we like (*listed in no priority order*):

- *Extraordinary, novel*: apart from the everyday routine/experience
- *Ephemeral*: lasting for short periods of time (and “live”)
- *Social*: sharing an experience with others
- *Sensory*: seeing, hearing, smelling, tasting, touching
- *Playful*: having fun and immersing ourselves in the experience
- *Educational*: finding out something we didn’t know before, sense making

These observations in the field thus far helped me to identify one dimension, a starting point for developing a “wonder” framework to scaffold novices through a learning journey or quest.

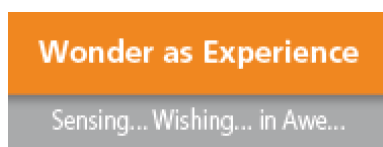


Figure 8: A beginning of the wonder framework: Wonder as Experience – sensing, in awe/awestruck; a receptive affective, passive state.

I knew this one dimension would not be sufficient to move students into deep learning, especially during those times when they may not be as motivated as when seeking out a “wondrous” experience. I suspected however, that the “inspired” quality of this aspect of wonder might play an important role in motivating students – perhaps to jumpstart them at sticking points along the way. (Figure 8)

And so my “wonder” journey continued. How does wonder work? How often do people wonder? Do they wonder in their every day, out in the world, on the streets? Or do they just go about their daily routines “with eyes dimmed”?

Deconstructing Wonder (Components of Wonder)

Let’s dissect wonder to see its component parts. Parsons discusses this in depth in “A Philosophy of Wonder” and dissects wonder into these parts:

1. **Subjective wonder** (affective, receptive): [A person] undergoes an emotion – an intense feeling which submerges perceptual, conceptual, active powers. It subdues his capacity.
2. **Objective wonder** (effective, active): When wonder comes from one’s own effort – giving form, meaning molding activities, he takes part in the forming of one’s experience. It augments his capacity.

We explored this notion of “subjective” wonder (affective, receptive) in our field observations at the Aviary, Phipps Conservatory, and the nature web cams. But did we observe “objective” wonder, the “effective, active” dimensions of wonder?

The experiences revealed that yes both dimensions of wonder (i.e., subjective and objective) could be accounted for; however, one might have been more explicitly obvious than the other. Individuals experiencing the objects of wonder in the moment were in the “affective, receptive” state, while implicitly or less obviously (and probably taken for granted) the “effective, active” dimension of wonder was embodied in the form (i.e., the venue itself). We humans create these venues so that we can experience wonder and in that creation is the “objective wonder” component “augmenting our capacity for wonder”.

But does “subjective wonder” actually “subdue our capacities”? In the way Parsons is describing wonder, yes. *“What gives an experience the quality of wonder or wondrousness is ... a sense of sharp novelty in qualitative awareness (sense, images) and (secondarily) in meaning.”* (Parsons, pg 85)

Note that what he is saying is that while our senses are awakened “Wow!” with subjective wonder, we have not yet begun to search for and articulate meaning, which is determined by and takes “[one’s] own effort” to question, seek, and form (new) meaning. *“... ‘wondering’ in the active voice indicates the formative, intentional force that aims at putting into meaningful form the relative disorder of the emotional experience.”* (Parsons, pg 93)

Parsons lays out the wonder meaning-molding progression in this way:

“wonder” → “wondering” → “knowledge” → “control”

And he acknowledges that subjective and objective wonder can be simultaneously experienced. “These two modes of experiencing wonder may of course be mixed, so that both being created and creating are felt simultaneously.” (Parsons, pg 93)

Evoking and Sustaining Wonder

In *The Varieties of Wonder*, Patrick Sherry discusses the openness and intentionality of wonder. He makes a point that wonder requires openness, not attention, but goes on to describe the affect of that openness as attention. To awaken in people the will of wonder, we don’t command them, “Pay attention!” Rather, we direct their attention for example, by pointing to a plant’s blossom and saying, “Just look at it opening out!” (Sherry, pg 10)

Wonder is evoked when we are awestruck, but it is sustained through the act of questioning, searching for, articulating, and creating meaning.

“What men lose in the arts that rely on sound and sight they gain in wealth and continuity of meaning which these can evoke and sustain.” (Parsons, pg 99)

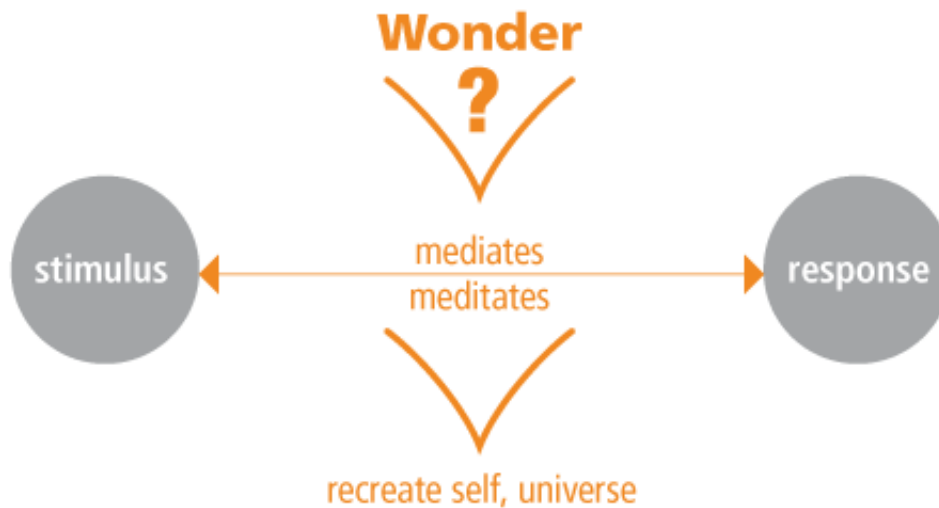


Figure 9: “Man's imaginative machinery mediates (meditates) between stimulus and response; and in mediating, in wondering, in the tower and the play room of thought, he begins to recreate himself and the universe.” (Parsons, pg 90)

We can use the above active wondering explanation to think through our observations in the classroom (Figure 9). What is the stimulus for wonder the students will experience? What is the response that will occur and what is it we want to elicit? And how shall they be guided to meditate between the stimulus and response to make connections and create new meaning?

A case study: observing wonder in the classroom

Here I will provide a detailed description of the *Dexign the Future* course where, through a focal lens of wonder, I spent a semester observing students. Given the complexity of the context including a core requirement of the course “to take imaginative leaps into 2050,” students would surely need to wonder, wouldn’t they? This context was to provide a fruitful venue for observing the role wonder might play for learning.

The Class: Dexign the Future

Dexign the Future was a semester-long elective course co-taught by Arnold Wasserman and Peter Scupelli in the fall of 2013. It was offered by the School of Design, but was open to students from other disciplines at CMU.² As indicated in this excerpt from the course syllabus (below), students are immediately confronted with domain-specific lingo and unfamiliar design processes and methods that they will be expected to use to both understand the course concepts as well as complete the

² DTF was a 12-unit design studio team-based project course originally designed with graduate students in mind, but open to upper class undergrads. It turned out that of those enrolled, most were undergrads. There was a lot of material and not a lot of time for the undergrads to complete the readings. This is because for undergrads, this is a 9-unit course, which means per week, these students spend 6 hours in class and 3 hours outside of class.

project work. This meant that all students were novices and thus offered a level playing field for observing wonder.

The goal of this course is to engage you in the integrated reality of the design world through a semester long project situated in Pittsburgh circa year 2050. You will learn to use long-range strategic scenarios to understand the forces that create change that shapes the design of material culture, communication environments, services, lifestyles, social interactions, and community. The focus of the course is to create design scenarios for sustainable lifestyles (e.g., home, work, learning, health, community, mobility, play). It is our core belief that, the slogan “Design the Future” is an open invitation for designers to rise to the challenges that threaten our collective future and seize the opportunities that turbulent change affords.

It goes on to explain the connection of this course to wicked and super wicked problems and that traditional approaches fall short and design agility is required for designers shaping futures:

Shaping the future is a wicked problem. Wicked problems are often described as difficult problems to solve due to incomplete, contradictory, and changing requirements. Wicked problems are contrasted to relatively tame problems where the actual problem to solve is easily defined. Wicked problems cannot be solved with traditional approaches where the problem is defined, analyzed, and solved in sequential steps because there is not clear problem definition (Rittel & Webber 1973). Examples of wicked problems include economic, environmental, social, and political issues. Super wicked problems include issues such as global climate change where time is running out, there is no central authority, those solving the problem caused the problem, and policies discount the future (Levin, Cashore, Bernstein, & Auld 2012).

When working on super wicked or wicked problems design agility is necessary. All design tools, methods, and processes have strengths and limitations. Designers demonstrate design agility when they quickly adapt their tools, methods, and processes to different contexts quickly and appropriately. Shaping futures defined by uncertainty and change requires design agility. (The full syllabus is available in the appendix.)

In short, given this description, one can conclude that the coursework will require expert-level design processes and thinking. As such, one might expect pedagogical approaches that make these expert processes accessible to novices, including pedagogical activities that set the stage for wonder. Some of these approaches were apparent in the course design (e.g. modeling expert thinking); others were not so apparent (e.g. intermittent timely practice with design methods, activities aimed at building metacognitive skills that involve interrogating one’s own understanding).

Pedagogy: content, format, learning objectives, delivery:

This project-based studio course had all of the ingredients for the makings of a wonderful, enriching experience. The question was never about is this a good course – the answer to that question is a resounding, “Yes!” The question was about whether it could have been better attuned to students learning needs (i.e., developing expert-level thinking and processes)? And again the answer is “Yes.” In fact, the instructors anticipated as much, writing:

This is the first time that we’re teaching this course and it intends to accommodate a wide variety of student interests and the enormous evolutionary leaps taking place in the field. As a result, there are bound to be some “bumps” along the “journey of discovery” that we’re taking together. We hope for and appreciate your suggestions and constructive criticism of what works and what doesn’t, and generally how to make this course great.

Areas and degrees of expertise of those participating in the course:

The newness of the course, an emerging field of study, new approaches and methods, wicked and super wicked problems, the fact that it was an elective – all of this meant that it was a level playing field for students – they were all novices in this context. It seemed a perfect vantage point from which to observe wonder. Notice in Figure 10 below the distinct gap between experts and novices. We need to move students in the direction from the bottom left to the top right if they are to develop expertise.

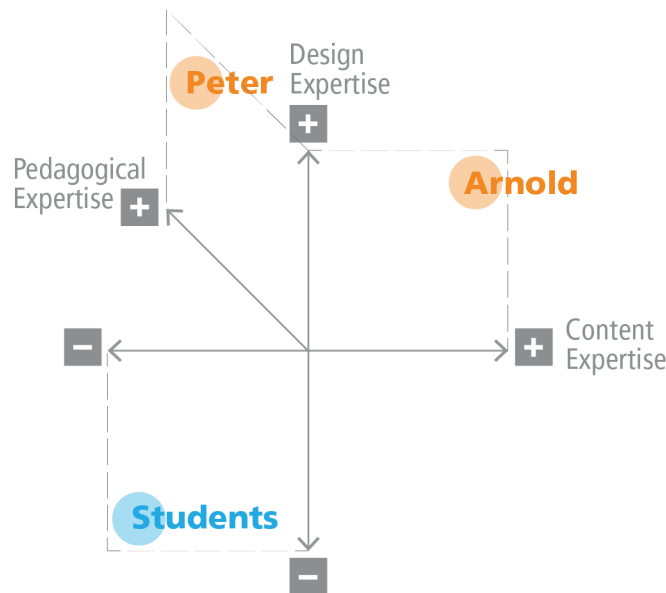


Figure 10: As observed in the *Design the Future* course, students are entering as novices with no content area expertise and with either none or minimal design background. But you can also see that while each of the faculty is a design master, one is less familiar with the content area and the other with the design pedagogy. Everyone is operating as a novice in some way.

Course Content:

There was an abundance of content that students were expected to navigate productively.

- *Course website:* The faculty provided a course website containing a wealth (dare I say, an overabundance) of rich, relevant content. The course site was approximately 35 pages of text including a day-by-day syllabus that embedded many and extensive information resources, including links to external sites; and documents, presentations, and videos from the instructors’ professional practices as well as other industry experts and organizations.
- *Course wiki:* A course wiki was set up to provide a place for students to submit weekly reflections, as well as to provide them with additional information resources (e.g. design research methods relevant for field study and synthesis, persona scenarios, and more).

Here I pull an excerpt from my classroom observations on day 4 of the course to give you a sense of the sheer amount of information the students were already exposed to at that point:

Instructor: “What we’ve done in this course so far is to push a lot of stuff at you guys to immerse you in several worlds that you might not have been too familiar with – ways of contrasting, ways of thinking about the future; and for Monday more ways to think about the future. We wanted to immerse you and fry your brains a bit with the diversity and scope of thinking that goes on in a world that for the most part designers, like us, don’t take part in.

Here we have the faculty informing students that there is, as intended, a tsunami of information coming at them – enough to “fry your brains.” While one might feel invigorated in the moment, I have already discussed in some detail the differences between experts’ and novices’ cognitive networks, hence the significant challenges for novices to efficiently and effectively use information and to question and further guide their own discovery. This difference was observable in the classroom setting.

Format:

The format was typical for a design studio course:

- *Lectures and guest speakers:* to transmit a great deal of background information to students to draw upon for their project work. Many hours were devoted to providing students with exposure to concepts, practices, and work products of businesses engaged in designing the future.
- *Group projects:* semester-long group projects where students were required to conduct field research and develop and present future scenarios.
- *Student presentations:* students presented their work as phased deliverables became due.
- *Critique:* faculty critiqued student teams’ work at each phase.

However, the amount of time spent on each aspect was a bit out of balance. That is, there was an overabundance of time spent lecturing prior to students actually working with the material; and time spent on practice with component skills was for the most part absent.

I acknowledge that some faculty may declare that the project work is the intended opportunity for practice with the new methods. I do not disagree; however I put forth that it was the timing and scope of the project work that was (for a novice) too disconnected from the front-loaded information tsunami. Again, it’s the difference between experts and novices and attempting to give students practice with the steps that experts do but that they do not explicitly think about as steps in a process. I have discussed earlier from the research literature and will show later results from the sessions I ran with students, that providing students with just-in-time skill-building activities (as concepts are being introduced) does support their integration of new concepts and efficiency with getting up to speed using new methods.

Delivery:

- *Face-to-face:* Course was taught synchronously face-to-face, with one instructor teaching remotely via videoconference.
- *Design studio physical location:* Students met in the design studio classroom.
- *Online content and information exchange:*
 - Material was delivered via an open course website and a closed wiki.
 - Students posted their work online via the course wiki, their own personal blog, and team project websites.

The design studio classroom setting was an ideal space for flexibly moving from full class activities to individual project team collaborations, had full-wall whiteboards to support team thinking, and technology to support communicating remotely and student team presentations. The online venues provided students with a way to asynchronously access content and communicate and collaborate as needed.

One complexity with the delivery was with the remote teaching component. The technology was at times glitchy; and the remote faculty member commented on having problems “reading” students’ body language. This was notably not ideal, however it was also not the main focus of the issues students experienced in terms of barriers to their learning.

Learning Objectives:

I will go a little in depth here with the learning objectives as they have the potential to be a great utility for students and their self-directed learning decisions. Below, I have pulled out two of the four lists I found posted in the syllabus and the course website. I put forth that there is a lack of clearly articulated student-centered learning objectives, which leaves students a bit in the dark about what exactly it is they are engaged in doing.

There are a number of places where learning goals and objectives are listed and vary in their descriptions. This list is from the course syllabus:

In this course you will:

- Understand the role of designers in an explosively dynamic field / profession in a radically transforming world. Challenge yourself to push the boundaries of what you think you can do as a designer.
- Learn the tools, skills, resources required to be a proactive agent of positive change in the planet.
- Learn from researchers and professionals across campus and the Pittsburgh region.
- Gain teamwork experience to understand how high performing multi-disciplinary teams operate. Work and learn from and with each other, in small teams, and as an entire class.
- Integrate rigorous design process and design research. Conduct exploratory, generative and evaluative research, throughout the design process. For each step of the design process you will learn to demonstrate mastery of design methods, design research, and presentation.
- Create design artifacts that demonstrate your understanding of a four step design process: (a) definition, (b) discovery, (c) concept, (d) refinement, reflection, and communicating your design.

Here’s another variation of learning goals and objectives taken directly from the course website:

In this studio course, students:

1. Explore your role of designers in an explosively dynamic field in a radically transforming world.
2. Learn to use long-range strategic scenarios to understand the forces that will create change to shape the design of not only material culture but the institutions and policies that shape democratic society.

3. Develop the tools, skills, resources required to be a proactive agent of positive change.
4. Collaborate with researchers, professionals and change agents across the CMU campus and the Pittsburgh region as well as remotely.
5. Gain teamwork experience to understand how high performing multi-disciplinary teams operate on complex, wicked problems.

There are another two learning-goals-type lists found on the course website which also vary in their descriptions.

Again, the reason I point this out is that student-centered learning objectives are critically important to communicate clearly to students. They are a key component of the course design – they should be measurable (for evaluation purposes) and therefore course activities are aligned with these learning objectives and what is being evaluated, to provide students with the necessary practice for mastering the skills and sub-skills embedded in these objectives. (Ambrose, et al)

As the syllabus is the contract with students, the list in this document would be the set to remember. However, given students may read the syllabus once and need to use the website daily to access the schedule, required readings, etc., they are likely to more readily run into these various objectives.

The lack of a go-to list of clearly articulated learning objectives undermines their utility for students. With numerous and varied learning objectives made available to students in various ways (e.g., syllabus, course website, verbally), it is unclear which objectives students should prioritize and set their sights on achieving.

One might suggest that the syllabus offers evaluation criteria which signals to students what they should be doing/learning. However, taking a closer look at the criteria listed, it could be argued that they are quite vague/abstract; and would require unpacking that which the faculty expert has in mind in order to make these understandable to the novice. Table 1 shows a representative sample of the evaluation criteria provided to students in the course syllabus:

Criteria	Levels of achievement		
Stage 3 Concept	Sophisticated	Competent	Not Yet Competent
Connection to research	Deep and logical connection between research and concept directions developed	Some connections to research conducted, but other important findings are not addressed	Little or no connection to the research conducted

Table 1: Sample evaluation criterion excerpted from the DTF course syllabus: seems vague in light of the different and many sets of course/learning objectives listed in various places (e.g. course website and syllabus).

The criteria appear to be communicated by experts to experts. How will a novice translate what it means to make “deep and logical connections”? Further critique might reveal that the criteria could also be more specific and explicitly tied to measurable student-centered learning objectives.

To illustrate the significance of a clear set of student-centered learning objectives, I will take one of the objectives from the list provided in the course syllabus and attempt to make it student-centered, actionable, observable, and measurable. Let’s take a closer look at this objective:

Learn to use long-range strategic scenarios to understand the forces that will create change to shape the design of not only material culture but the institutions and policies that shape democratic society.

Does this communicate clearly enough what is required of the student? What do you think is involved in achieving this objective? Below, I have attempted to unpack this objective into six sub-objectives or skills, according to my understanding of the course content and intended design process for accomplishing this objective.

1. Describe the global forces of change in 2050 as identified by the WBCSD (information provided on the course website).
2. Identify and describe the forces of change in Pittsburgh 2050, drawing from the global forces, additional information provided on the course website, plus data you’ve gathered from your local field studies.
3. Identify 5 themes (e.g. sustainability, economic equality, access to education) that have emerged from the information and data you are choosing to use.
4. Define the top 5 most influential institutions, policies, and aspects of material culture shaped by these forces.
5. Create future scenario concepts that integrate the forces of change you identified and relate the institutions, policies, and material culture of Pittsburgh 2050 with those forces and other relevant findings from your research.
6. At each step throughout your process, reflect and question to develop new understanding: create self-explanations about what you know and list questions you have about what you don’t know; and the relevant sources you might consult to find answers.

Notice how the order moves from “using” information provided by the instructors to achieve particular sub tasks towards less “given” and more “self-driven” actionable learning objectives. Working with an initial more structured model for practice provides students with the scaffolding to succeed early and with that success move onto more complex and transferable tasks. Note how this list also provides an explicit objective for developing students’ metacognitive skills.

Now let’s look at the evaluation criteria again. With the student-centered learning objectives in hand, one can begin to understand what it means to have “deep and logical connection between the research and concept directions developed.” One could take this a step further and improve upon the level at which these criteria communicate to novices what is being measured, by further unpacking based on the revised learning objectives; with the goal of making it even clearer to the student the alignment between his/her learning actions and the criteria against which this behavior will be measured.

By unpacking the original learning objective into measurable student-centered learning objectives (skills and sub-skills), we can accomplish several important goals:

1. *Modeling the process*: make the expert thinking and processes explicit and visible to novices.
2. *Actionable*: make the learning objectives something students can know how to act on (and to use to prioritize and guide their efforts).
3. *Observable and measurable*: “Am I doing it right?” Make the learning objectives observable and measurable by instructors (and students as they evaluate their own work and, when required, their peers’ work).

4. *Self-Directed*: make wonder an explicit part of the model and process (as this is a key driver of expert practice).

If students are to develop expert thinking and processes, why not provide them with explicit targeted practice (and feedback) to do so? Part of the expert’s process is wonder. It, along with the other steps in the expert’s process, should be exposed and accessible to novices as they develop into experts (whose knowledge too will become tacit overtime and the cycle of making the invisible visible begins again).

Teaching and Learning Activities in Class

I’ve already discussed the tsunami of information the students received and the lack of clearly articulated student-centered learning objectives. Next, I will discuss the various observed classroom activities and students’ behaviors, as they relate to wonder. In short, the lab visit, field work, and guest speaker occasions were the activities where wonder was most frequently activated (Table 2).

Aspect	Passive Wonder	Active Wondering	Sustained Wonder
Pedagogical Activity			
Lectures (content exposition)	–	–	–
Collective Invention guest speakers	+	–	–
Pittsburgh 2030 guest speaker	+	–	–
Ideate guest speaker	+	–	–
Collective Invention guest speakers	+	–	–
Create Lab Visit	+	–	–
Class discussion	–	–	–
Individual student reflection	+	(For a few)	
Field Work	+	+	–
Team Project Critiques	–	–	–
Design Phases			
Phase 1 Definition	+	–	–
Phase 2 Discovery	–	+	–
Phase 3 Concept	–	–	–
Phase 4 Communication	–	–	–
Persona (student type, see page 30)			
Evan	–	–	–
Kim	+	–	–
David	+	+	–
Priscilla	+	+	+

Table 2: As observed in the *Design the Future* course, wonder was frequently present in the passive form, but did not transition into active questioning or sustained wondering. The personas (shown on page 30) are a compilation of traits. Priscilla is the one who is acting more like an expert in her ability to wonder for learning – she actively shapes and quests for new knowledge and discovery.

In Table 2, you will notice that quite a few activities worked to initiate passive wonder (i.e., the students were the passive recipients of something quite new and stimulating). The sheer volume and type of information provided, the enthusiasm of a guest speaker, and the visits to labs were influencers for initiating wonder.

One of the biggest suppressors of active wondering was the sheer amount of one-way information transfer during the lectures as well as during critique; and these two activities comprised the majority of class hours. (Approximately 80% of the semester in-class time was spent on lecturing and individual team presentations and corresponding instructor critique). While presentation and critique are also high value activities, I put forth that these did not directly require students to drive their own interrogative processes. Rather, students were operating in a passive, receiving mode vs. an active, effective mode.

Of the 66 hours of class time pedagogical activities that I directly observed, I coded 14 of those hours as promoting active wondering (or put another way, a high degree of inquisitive interaction between novices and the experts and the material). For example, when a guest speaker presented to the class the new IDeATe cross-disciplinary curriculum design, he engaged students in active discussion, guiding them to make connections between the concepts and examples they raised to information, trends, forces, etc. that he had been discussing. He was able to accomplish this through the use of a few effective techniques including:

1. *Maintaining students' attention:* He actively moved away from the central lectern through the room pointing at the information he was projecting, and roamed around where students were seated.
2. *Opening students up to participation:* When students did not respond to the first question he raised, he broke the ice, saying in an up-beat friendly tone with a smile on his face, "Come-on just be honest guys." After which, many hands raised to respond to the question.
3. *Relating content to students' backgrounds:* When students did participate, he asked, "What's your background?" and then related his response to his/her disciplinary background (e.g. Electrical engineers: current trends and new skills they will need to have entering the future workforce; and how the curriculum framework operates to meet those emerging needs).
4. *Modeling/guiding a logical line of questioning:* He expanded on students' comments saying, "Let's take what you are saying..." and drew it out on the whiteboard juxtaposed with the IDeATe curriculum design framework; and questioned it further."

In hindsight, the behavior students exhibited in this one class session would be the most actively engaged they would appear in a classroom discussion all semester. I put forth that what we witnessed here was the range of wonder experiences: Openness (opening students to wonder) → evoking wondering (by making it personal, relatable to students) → sustaining wonder (causing students to question further and literally draw out new meaning).

So why then did the regular classroom discussions fall short – where was students' wonder during these times? A few reasons have been discussed already (e.g. novice's sparse superficial organization of knowledge). It seems evident, however that expert's blind spot clearly played a role given the sheer amount of information students were expected to consume and productively use. Students needed time to connect the incoming information to their existing knowledge structures as well as

time to articulate that outward. The speed at which this information transmission was happening just did not afford the time for novices to think and practice in the moment.

Ambrose, et. al. suggests that instructors can help students see connections they want them to see by aligning the organization of knowledge with how they want students to retrieve it, as well as by using simple strategies like highlighting important concepts and using prompt questions for directing and focusing their attention as they read. (Ambrose, Lovett, et. al.)”

What challenged students most? Where did breakdowns occur?

While students received a wealth of information beginning on day one, they did not receive sufficiently scaffolded practice with how to use this new information (and new methods) early on in the course. For example, a visit to Carnegie Mellon University’s CREATE Lab on day 4 was scheduled so students could see the future in the making.

The CREATE Lab is both a technology breeding ground and a community partner. It is this unique combination that enables a new form of local change: one that empowers the citizens to chart their technology future and, most important of all, their community’s prospects for quality of life. (<http://www.createlab.ri.cmu.edu>)

As the tour began, the guide asked the students if they had any questions. Students did not respond. The tour guide went from project to project describing all of the cool things they are engaged in making and doing, but still the students had no questions. The instructor asked many questions, with the intent that the students both hear the types of questions he was asking as well as hear the responses to those questions. He would then prompt the students to ask questions. It was visible that the students were attentive (moving up close to various projects, occasionally touching/examining things), but they were not asking questions. It was only towards the very end of the visit, when a couple of students asked a few questions. Following the visit while walking back to class, the students were chatting very excitedly about how cool everything was and how it was so interesting to see all of this work.

“The content of a problem – whether it be about sex or human motivation – may be sufficient to prompt your interest, but it won’t maintain it.” (Willingham, pg 9)

However, it was also clear that they had not connected this work to the course. As mentioned previously (on page 2), in the classroom follow-up discussion when instructors asked students about what they saw – weak signals, future forces – students responses were predominantly affective: “I really liked that project... It is cool that they are doing that work.”

What was the failure? What we are seeing here is one aspect of wonder: *“the relative disorder of the emotional experience”* (Parsons, pg 93) and from our wonder framework: “wonder as experience.” The senses are awakened. But, contrary to what one might assume that students are making no effort to make meaning, I’ll leverage Lovett’s metaphor for sparse knowledge networks and argue that students are grappling with “roadblocks” to the meaning making. They need help from the experts. They need help to see, to make the connections that instructors want them to make. As mentioned earlier, the learning objectives are key to organizing the information and structuring activities that will set students on a course of action and in such a way that students will retrieve knowledge as

intended by the instructors. Additional guidance along the way can be provided through strategies such as directed prompts and highlighting (Ambrose, et al). Here at the CREATE Lab visit, students needed such guidance. The novices needed the experts to be aware of the expert’s blind spot and to make the steps of meaning-making visible, accessible to the novice.

Students are primed at this first phase of *wonder as experience* to begin to search for and articulate meaning, but their effort needs guidance/direction if they are to make connections and form new meaning. Providing scaffolding as students enter into dialogue with the new concepts and methods of the course is critical.

This brings us to a second aspect of our framework of wonder:
“*wonder as interaction.*”

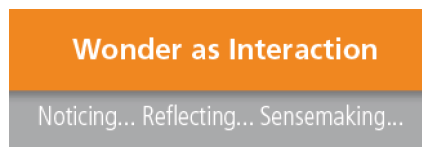


Figure 11: A second aspect of the wonder framework: Wonder as Interaction – consciously noticing, reflecting, sense making; an effective, active state.

While the instructors did say to the students prior to the tour that they should ask questions and think about signs and forces, there was an assumption that students would know what questions to ask.

In Figure 12 below, I have layered the CREATE lab visit onto the “active wondering” visual explanation (Figure 9 on page 16). What is the stimulus for wonder the students will experience? The cool CREATE Lab projects. What is the response that will occur? Enthusiasm, awe. What is the nature of the interaction we want to elicit? We want students to make connections from the CREATE Lab to the course concepts and use those connections for their project work. And how shall students be guided to meditate between the stimulus and response to make connections and create new meaning?

I propose that this mediation, guiding piece of the puzzle is missing. We need to do something to explicitly guide the novice’s behavior toward desired responses (i.e., expert thinking, processes, and desired learning outcomes).

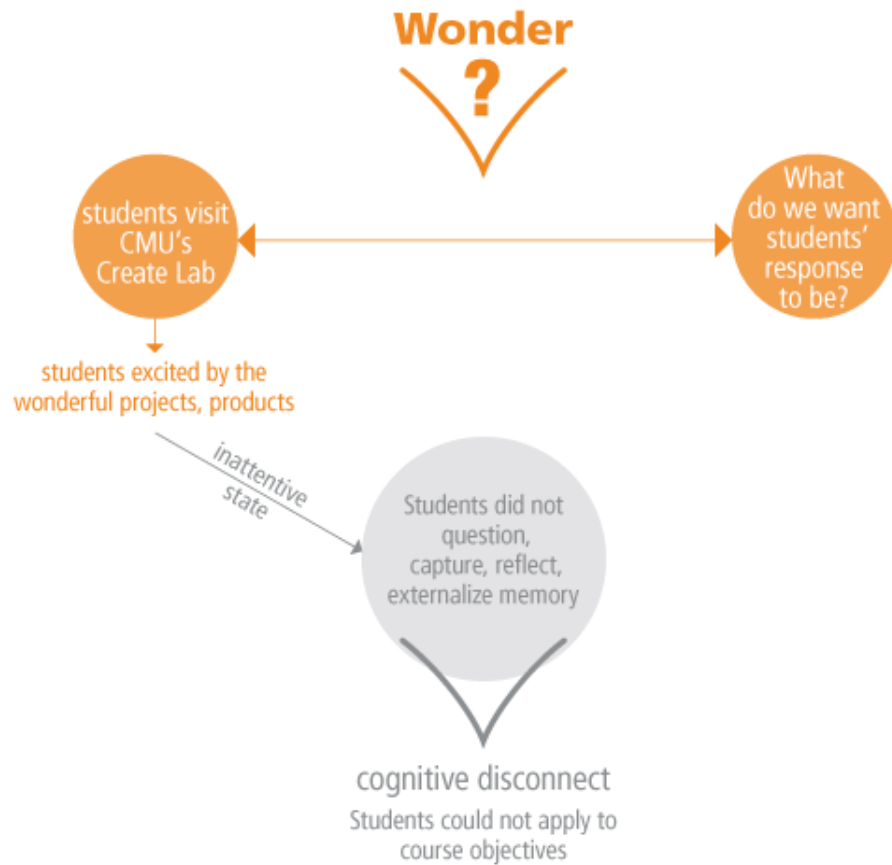


Figure 12: The CREATE Lab visit was filled with wonder and students were excited to see all of the projects, but they were unable to engage in active wondering; they appeared not to be making connections to the course concepts.

What could have helped? There are any number of more or less scaffolded activities that we could have engaged to provide students practice with active wondering including:

- Taking a page from the IDeATe presenter’s playbook (e.g., modeling/guiding through a logical line of questioning). We could have used 20 minutes of class time prior to the visit to work with students through one CREATE Lab example, logically questioning and connecting it to forces of change.
- Doing an exercise where students would take 15 minutes to create a concept map using one of the CREATE lab projects.
- Using a concrete example from the readings to explicitly tie the CREATE Lab projects to various pathways in the WBCSD pathways report.

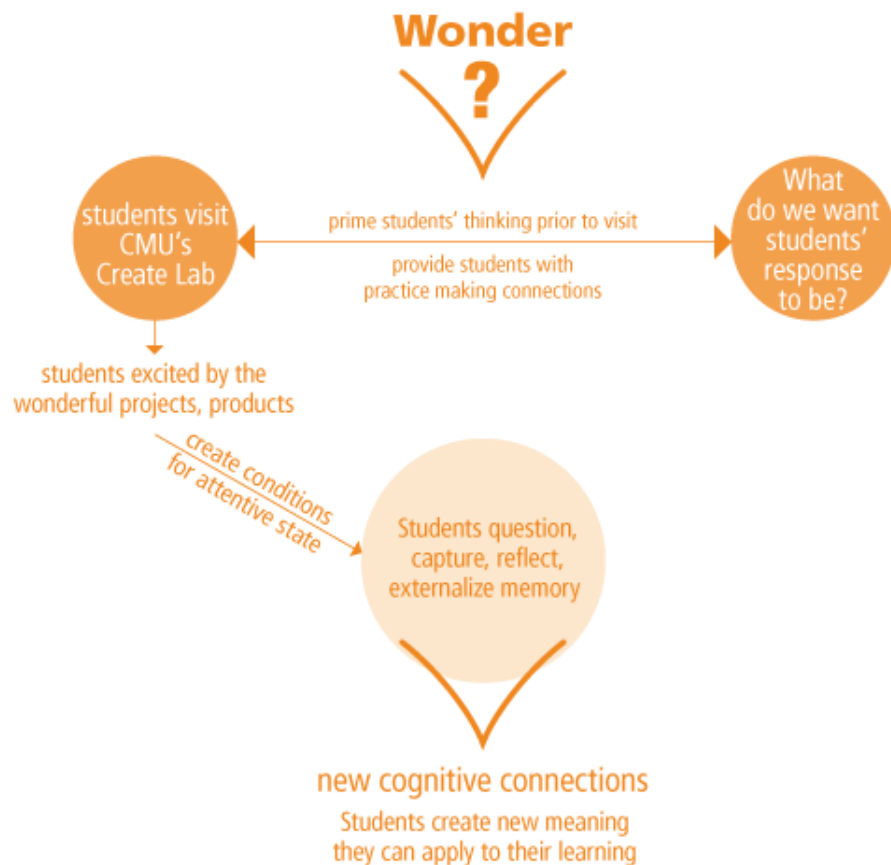


Figure 13: The CREATE Lab visit was filled with wonder and an opportunity for active wondering. Providing explicit, concrete, scaffolded practice with expert thinking and processes could have supported students with making new connections.

This kind of practice with expert processes immediately followed by application in the CREATE Lab context would have efficiently moved students along the wonder framework: from a state of awe, to directed deliberate interaction with the material where students are making new connections, to situating them towards active wondering where they are making new meaning and on a quest for learning. (Figure 14)

This brings us to a third aspect of our framework of wonder:
“wonder as action.”

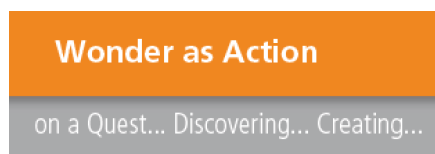


Figure 14: A third aspect of the wonder framework: Wonder as Action – on a quest, discovering, creating/making new meaning; an effective, active state.

What we observed throughout the semester was that students suffered from a lack of active and sustained wondering, appearing initially intrigued followed by signs of disconnect, retreat, and at times resistance. Occasionally, a student would re-emerge; summon up a degree of grit, and lead the way forward. The classroom observations were providing a window where I was beginning to see categories of student/novice traits emerging. It was time to sketch a few personas as compilations to help distinguish and articulate their stories. With the three components of wonder in hand, I wanted to see where each persona might predominantly situate along a continuum of ways we wonder (Figure 15).



Figure 15: A continuum of ways we wonder: from wonder as experience to wonder as interaction to wonder as action.

Persona Types...



Evan: *Know-it-all!* (Paradise Mine/Blank Canvas)

Passive-Internalizing: Evan makes a lot of assumptions. He is resistant to other's perspectives and integrating those into his own model of how the world works. He does not externalize or concretely represent his thinking in order to explicitly challenge his assumptions or evolve as new information is presented. While Evan is sensing, feeling the amazement of wondrous people, places, things, and experiences, his lens is narrowly focused through unchallenged thought and therefore his experience of wonder is limited to a single moment in time.



Kim: *Quiet Explorer.* (Paradise Lost/Untold Story)

Active-Internalizing: Kim is generally a critical thinker in that she reads her homework, takes time to think about it, and at times asks really good questions, but she is not productively externalizing her thoughts and finds herself blocked as a result. There is just too much information and she doesn't know how it all fits together. Kim wants the instructor to tell her *exactly* what to do next. While Kim is sensing, feeling the amazement of wondrous people, places, things, and experiences, she is experiencing overload given all of this new information and questions she has for it. Her ability to act is blocked. She is unable to focus her attention and make appropriate connections to the new knowledge. She is stuck in the experience of wonder, and though willing, is blocked from productive interactions that will lead to further action and new knowledge.



David: *Cautious Loner.* (Paradise Unknown/Lost Opportunity)

Passive-Externalizing: David is wonderful at communicating through drawing representations of known information about the problem and the solution. He is a bit guarded in his interactions with others and with new methods that fall outside of this comfort zone. This affects the degree to which he will pursue a line of questioning and actively seek answers, especially when talking to strangers is involved. While David is observing relationships, noticing in detail, and representing this beautifully through his visual representations, he is losing or limiting his opportunity to build new knowledge and represent that to the world – his actions and impact are limited and we all lose out as a result.



Priscilla: *Inquisitive Adventurer!* (Paradise Found/Desirable Future)

Active-Externalizing: Priscilla is on a quest for learning, actively questioning and challenging her assumptions. She is frequently externalizing her thinking; representing the problem space, modeling solutions, evaluating early and often, iterating, questioning, determining and prioritizing actions. Priscilla is actively wondering and is nicely situated to positively impact her learning and the world. However, as the semester progresses, even Priscilla becomes more resistant to trying new things, especially if she thinks this will negatively impact her “A” grade for the class.

These personas are constructed from a variety of characteristics, behaviors, and self-reported processes of those students observed. No one student embodied these personas. For example, no one student was the model “Inquisitive Adventurer,” but there were moments and glimmers of these persona-embodied characteristics and behaviors exhibited by those who momentarily acted with agency, in what appeared to be a comfort zone (e.g. when tasked with drawing out “a day in the life of a future persona,” those individuals who possessed drawing skills were visibly more engaged: asking questions and in discussion with their group members and the instructors). In the same vein, no one student represents the “Know-it-all.” Many students made assumptions (e.g. “Well, everyone in the world wants to have...”) at the beginning of the semester. Some students dropped those early

assumptions after they began collecting data for their team projects. Other students held firmly to their beliefs and either did not engage in finding evidence or looked only to that data which supported their assumptions.

SIDEBAR: We would like to acknowledge William Perry’s work on the theory of intellectual development, *Ways Students Think: Duality, Multiplicity, Reactivism, Commitment* (1981), where he describes student’s intellectual development in terms of four key aspects or phases: knowledge is absolute; knowledge is matter of opinion; opinions are not all equal; and knowledge is constructed and backed by evidence. We acknowledge that students are developing intellectually and there are additional strategies for targeting their learning needs given where they situate along this developmental continuum, though we will not go into further depth here on this topic. One would want to take Perry’s work into account to both understand who your students are and to integrate the kind of strategies that would work for your context. The idea of wonder however remains relevant for developing expertise and the personas we’ve developed here hint at levels of intellectual development.

Furthermore, many students were not externalizing their thinking (explicitly making connections, self-explanations). For example, at about a third of the way through a lecture, the instructor stopped to tell students, “Don’t let this material passively wash over you. This is a lot of new information. If I were you, I’d be taking out my notebook and drawing concept maps to help me to think, make connections.” Some students immediately responded to that suggestion by taking out their notebooks and continued to do so (intermittently) throughout the semester, while others exhibited this infrequently or discontinued the practice altogether.

To understand more about how the characteristic behaviors of each of these persona types impacts the novice’s capacity to wonder concretely, I compared and contrasted their behaviors along two dimensions: along one dimension, ways we wonder (passive and active wondering) and along an intersecting dimension, ways we think (internalizing and externalizing thinking). (Figure 16)

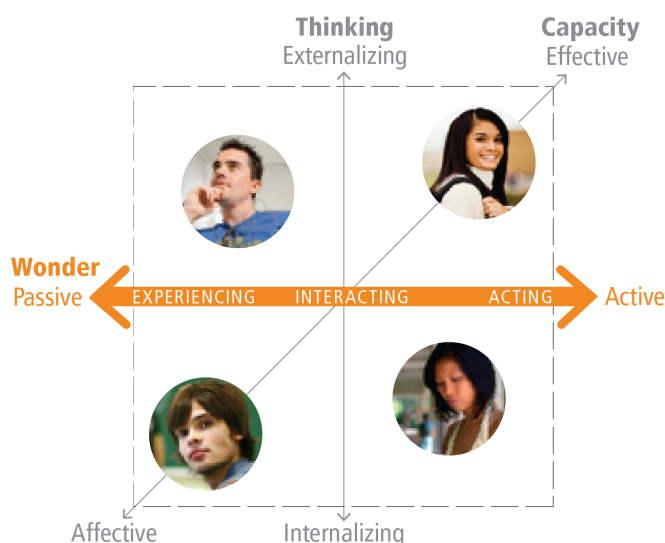


Figure 16: Comparing and contrasting behaviors along two dimensions (ways we wonder and ways we think), we can see where our personas fall in terms of their capacity to wonder their way into deep learning.

Ways we wonder–Ways we think:

Passive wondering–Internalizing thinking:

- Experiencing; sensing, feeling the amazement of wondrous people, places, things, experiences.
- Affective; asking a question with no intent to act; a question as a verbal reaction to a wondrous thing.

Active wondering–Externalizing thinking:

- Interacting, acting; observing relationships, noticing in detail; representing knowledge, explicitly making connections, self-explanations.
- Effective; carefully articulating a question with intent to seek to find answer(s).

In Figure 17, we can see where each persona type fits with respect to **meaning making**. How might we move Evan the “Know-it-all!” from the bottom left (i.e. meaning is dissociated, repressed) to the top right (i.e. meaning is integrated, created, given form)?

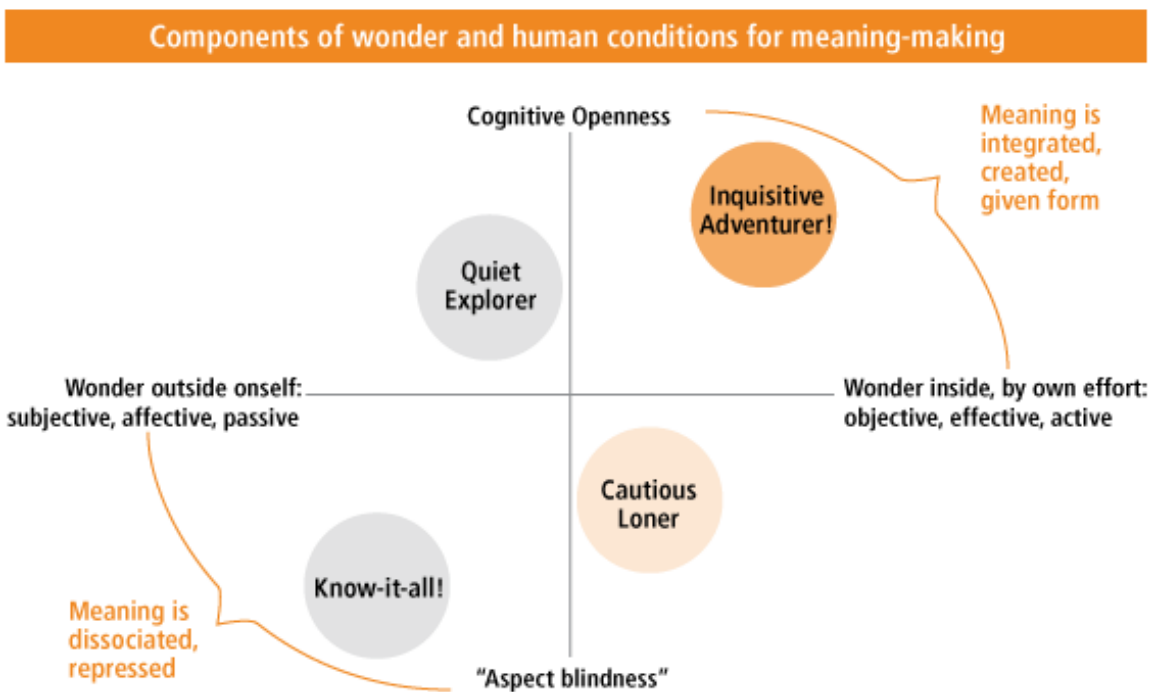


Figure 17: Here we have identified where the persona types are situated with respect to engaging in active wondering. When wonder is outside oneself, it is happening to us; it is causing an affect on us. When wonder is inside, by ones own effort, we are using wonder to actively understand and effecting change through the pursuit of new knowledge.

Because it would be critical to move Evan the “know-it-all!” into a better behavior pattern for active wondering, I drew out in more detail his persona scenario to attempt to reveal his thinking and understand his behaviors and challenges. Here’s Evan...

Persona | Know-it-all! (Paradise Mine/Blank Canvas)



Evan is an undergraduate student participating in a design studio course. He does not have very much experience with design work processes. Early in the semester, Evan expressed his excitement about this course and the possibilities of working toward design solutions for helping people. Initially, he was one of a handful of active participants in class discussions easily offering up opinions. As the course progressed, Evan participated less and less during class discussion; and then only when called upon. As part of the course grade, students are required to maintain a reflection blog. Evan posted many items once or twice early on in the course, but after the initial two weeks, he stopped.

Evan expresses his value for “the human experience” and human feelings. This value seems to dominate his thinking. While other students diagram possible pathways for their design projects (values, ideas, challenges, and solutions), Evan keeps thinking and when called upon speaks to these thoughts usually framed within the context of this dominant value. His instructor advises him to work on getting his thoughts out of his head and onto some format. “Use concept mapping or post-its to lay out and organize your ideas. Look for evidence: go out and observe and document what’s going on right now on the ground. Interview people to check your assumptions about what they think and feel and value.”

Still after many days, Evan is showing signs that he is not following this advice. Evan is one of three students in one of the project teams in the course. It appears his contributions to his team’s work are also at the level of thought, rather than material concrete deliverables. Evan has provided no evidence that he is externalizing his ideas beyond a bullet point or two in a presentation; no material artifacts to suggest that he has put his assumptions to the test. His contributions come in the form of Evan’s “truths” (e.g. You can’t dispute that everyone values X!) rather than questions he seeks to gain insight about (e.g. Does everyone value X as much as I do?). By mid-term, Evan appears to be locked down and not moving forward productively. The next step in the course is to create design solutions and yet Evan has no evidence to suggest that whatever he comes up with will matter to anyone but himself.

Because of Evan’s early enthusiasm in the course, we might conjecture that he is primed to begin to interact with the material of wonder, but we do not yet know where he is in his learning and what we need to do to move him to the next step. How can Evan be helped to achieve the learning goals? How can we motivate Evan to stay on path? How do we get Evan to consciously, deliberately reflect, and see the value, to self-motivate? By what means might we get Evan to externalize his thinking?

We can provide Evan with a few early scaffolded tasks where the actions of the task models expert processes, thus moving him forward slowly, deliberately to then begin to use the knowledge he gains for gradually more complex tasks. This would require clearly articulated student-centered learning objectives, scaffolding to guide Evan’s focus, and targeted feedback so he can experience early successes. It will also require a willingness on his part to participate. We will discuss aspects of motivation in the next section on “Evoking and Sustaining Wonder.” I think we have to acknowledge however, that regardless of whether you are Evan or Priscilla, a novice or an expert, there will be

challenges to sustaining active wondering as the design process moves us into a routine. This is where we can again look to expert process and actively seek out the use of heuristics to support reframing our views and re-contextualizing objects of wonder.

A notable challenge or tension between sustaining wonder and the design process:

Conceptualization, the instrumental attitude toward things, the development of mechanized habits, the creating and application of classes, with abstract types and subtypes of particular things – all contribute to extinguishing from awareness the qualitative uniqueness of things and hence the experience of wonder. (Parsons, pg 86)

Summary:

Here we have just discussed wonder in depth: what it is, components of it, how it works, observations of wonder in a classroom context, and why it’s important to learning. We have developed a framework for wonder and have discussed how it can be initiated, how we use it to interact with the material to develop new understanding, and the value of active wondering for meaning making. There are many ways we wonder. Active and sustained wondering are self-propagating enactments of motivation. However, as we’ve observed in the classroom, wonder for learning is not obvious to novices. Like Evan, some students did not engage their sense of wonder to further action. Why is this?

Next, we will explore the nature of motivation and agency to understand how we might be able to motivate students to wonder.

Chapter 2: Evoking and Sustaining Wonder

Up to this point, we’ve discussed three major topics: 1. Differences between expert and novice thinking and processes are significant. Novices need practice with these. At the core of experts’ thinking and processes is wonder. 2. There are various forms of wonder (affective, passive; and effective, active); and while it’s nice that we experience wonder, we need novices to move into active wondering if they are to develop expertise. 3. We’ve peeked in on a classroom where experts were teaching novices and observed where wonder occurred and where it did not occur. We found that while wonder was initiated frequently, only occasionally and intermittently did it convert to active wondering, and sustained wondering was all but absent.

At the forefront of what we now know is that we must make the invisible expert tacit knowledge visible for novices to grasp and use. That is, we need to unpack and expose expert thinking and processes. Student-centered learning objectives are a channel through which we can a.) expose and model expert thinking and processes; b.) provide the practice novices need to engage to elicit the kind of thinking we want from them; c.) set the course for and explicitly infuse into these objectives the practice of active and sustained wondering.

Daniel T. Willingham sums up an important barrier to thinking³ in this way:

Contrary to popular belief, the brain is not designed for thinking. It’s designed to save you from having to think, because the brain is actually not very good at thinking. Thinking is slow and unreliable. Nevertheless, people enjoy mental work if it is successful...

People are naturally curious, but we are not naturally good thinkers; unless the cognitive conditions are right, we will avoid thinking.

...teachers should reconsider how they encourage their students to think, in order to maximize the likelihood that students will get the pleasurable rush that comes from successful thought. (Willingham, pg 3)

Let’s break down Willingham’s point and connect it to our context here. As teachers (and designers), we might reconsider and question: 1.) How might we improve the cognitive conditions for thinking? 2.) How do we encourage/motivate students to think?

We have examined question #1 in our discussion about how using student-centered learning objectives would help to set up the right conditions for thinking (i.e. exposing expert processes which integrate active wondering), as well as using strategies to scaffold students’ ability to make new connections. We can leverage that context to think further about question #2. We did see students’ wonder (curiosity) initiate from time to time in the DTF course, but students frequently stopped short of active wondering (making connections between the object of wonder and the objective of learning). So then, how might we encourage students to wonder actively? How might we increase the likelihood that students will “get the pleasurable rush that comes from successful thought”? Here, we will look to the research on motivation in both learning and play contexts to see if we can find some answers.

³ Willingham defines *thinking* as: solving problems, reasoning, reading something complex, or doing any mental work that requires some effort. (pg 3)

Exploring motivation in the context of learning

Here I will reference the research on motivation for student learning which reveals that motivation is tightly linked to expectations for success. This harkens back to Willingham’s point that “people enjoy mental work if it is successful.” As this topic has been addressed in depth in *“How Learning Works: 7 Research-Based Principles for Smart Teaching,”* I will draw a great deal from the ideas discussed in that work to further address the question: **How do we motivate students to wonder?**

Initiating Wonder

“In the context of learning, motivation⁴ influences the direction, intensity, persistence, and quality of the learning behaviors in which students engage.” (Ambrose, et al, pg 69) Importantly, if either “value” or “expectancy” is not present for the student, motivation will suffer.

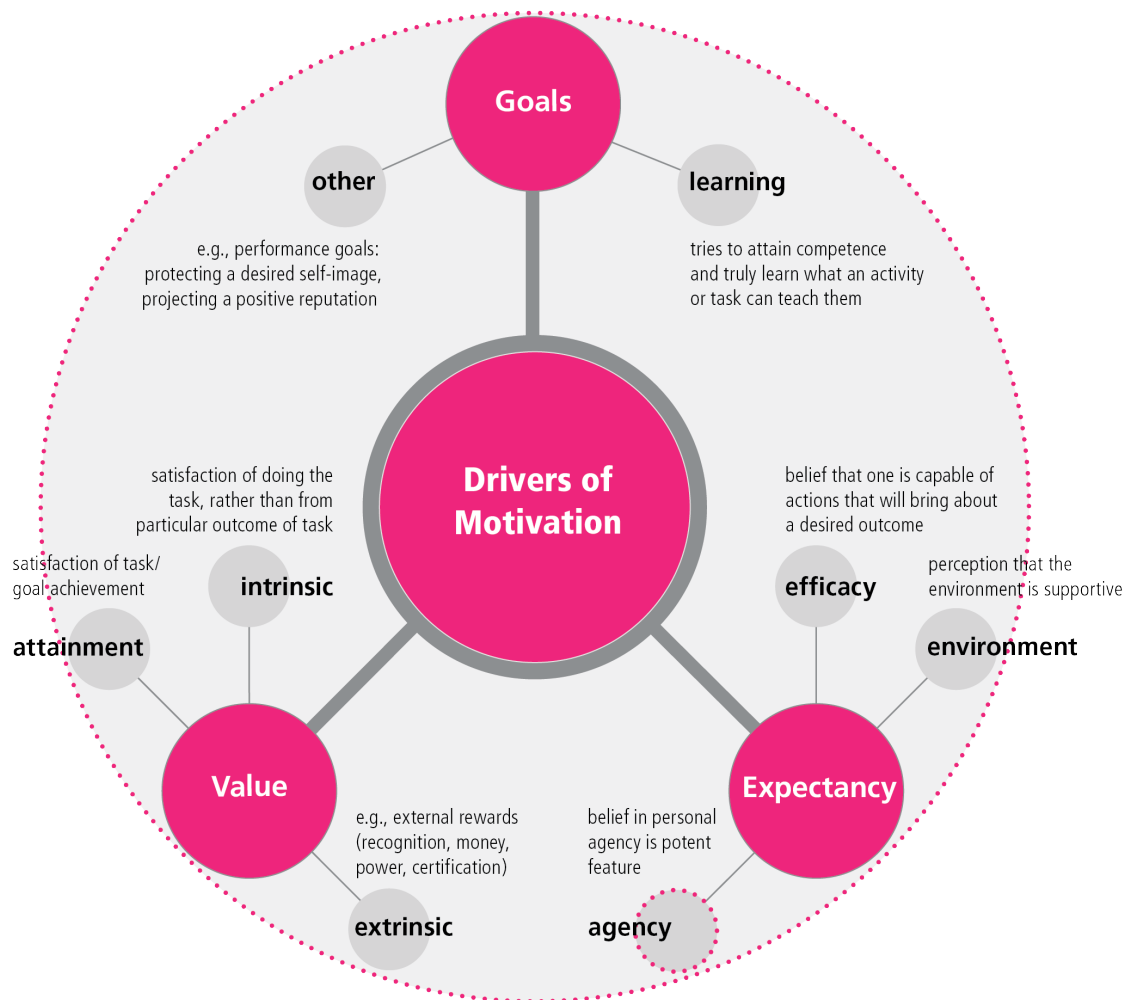


Figure 18: Ambrose, et al (pg 69) lay out three key drivers that influence motivation: goals, value, and expectancy; and they offer two important concepts central to understanding motivation: subjective value of a goal and efficacy or expectation for successful attainment of a goal.

⁴ “Motivation refers to the personal investment that an individual has in reaching a desired state or outcome.” (Maehr & Meyer, 1997)

How does motivation in the context of learning relate to our framework of wonder?

Motivation	Learning	Framework of Wonder
Goals	Direction	<i>Wonder as experience</i> is a way to draw one’s attention to something.
Value	Intensity	<i>Wonder as interaction</i> is a means for novices/learners to engage/interact with each other, with expertise, and with the subject matter.
Expectancy	Persistence	<i>Active wondering</i> is the means for continued engagement with learning, problem-solving, meaning-making.

Table 3: Relating components of motivation to learning and to our framework of wonder.

Looking at the relationship between motivation and learning in Table 3, one can potentially draw a similar causal relationship between motivation and wonder. Let’s explore a bit further how each aspect of motivation might work to increase or decrease the probability that students will initiate, engage, and sustain active wondering.

1. Goals: are the basic organizing feature of motivated behavior; “the compass that guides and directs a broad range of purposeful actions.” Learning goals are contrasted with other types of goals (e.g. performance goals, which involve protecting a desired self-image and projecting a positive reputation and public persona). Students who have learning goals, “try to attain competence and truly learn what an activity or task can teach them.” (Ambrose, et al, pg 71-72)

Given our discussion regarding expert practices, it would seem that experts are driven by learning goals – their thinking and processes are infused with learning goals. When experts wonder the goal is to “truly learn what the activity can teach them”; and their goals continue to direct that journey driven by new questions and a quest for meaning making. In the sea of chaos and turbulent times of wicked problems that novices now find themselves facing, learning objectives can play a critical role for guiding and focusing their efforts. Or to expand upon this concept from Ambrose, et al...

Learning objectives are “the compass that guides and directs” the novice’s active wondering.

But what about value and expectancy, how do these factor in?

Wonder as Interaction; Active Wondering

2. Value: According to Ambrose, et al, a goal’s importance (subjective value) is a key feature influencing one’s drive to pursue it. And a lack of perceived value can lead to a lack of motivation. A key insight here is that: “People are motivated to engage in behaviors to attain goals that have a high relative value.” They further discuss three determinants of subjective value for achievement-related activities and goals:

1. *Attainment value*: satisfaction one gains from mastery and achievement of a goal or task;
2. *Intrinsic value*: satisfaction one gains from doing the task rather than from a particular outcome of the task; and
3. *Instrumental value (i.e. extrinsic rewards)*: the degree to which an activity or goal helps one accomplish other important goals, such as recognition, money, certification, etc.

The key insight they offer here is that it is important to view these sources of value as potentially mutually reinforcing (Ambrose, et al, pg 75-76). For example, receiving extra points or a high grade for engaging in a learning activity (instrumental value) can later become intrinsic value as the student develops competence and is able to put into practice his/her newly acquired knowledge.

With the concepts of “goals” and “value” in mind, what levers do we use to motivate novices to wonder?

- a. *How do we get novices to interact with the material?*
- b. *How might we leverage this concept of “value” to instigate active wondering?*

As we look at the spectrum of wonder (from awe to meaning making), we can identify pinpoints of subjective value. We can then create learning goals (to promote interaction and guide active wondering) that leverage the reinforcing interaction of the various subjective values (attainment, extrinsic, intrinsic).

For example, of the six learning objectives I created on page 22, you will see that some are easier, more concrete, discrete tasks than others. One purpose for this is to provide students with opportunities for early success while building necessary skills or sub-skills, and therefore potentially increasing the value (e.g. early attainment/mastery of a discrete task, like drawing out the forces of change from a provided source, combined with an extrinsic reward like positive feedback or earned points, may lead to intrinsic value as the knowledge is later drawn upon for accomplishing more complex tasks). This is yet another reason why it is important to think carefully about and articulate “student-centered” learning objectives, infusing strategies that will tap and leverage subjective value.

Sustaining wondering

So then, what of “expectancy”? Do people pursue goals and engage the necessary goal-oriented behaviors when they do not expect a successful outcome? Well, as Willingham has suggested and according to Ambrose, et. al., the answer is: No.

3. Expectancy: *Outcome expectancies* reflect a belief that specific actions will bring about a desired outcome and the expectancy can be positive or negative. Positive outcome expectancy is when one thinks that the actions they take will yield a positive outcome. Negative outcome expectancy is when one thinks that no matter what actions they take they will not achieve the desired outcome. (Ambrose, et. al., pg 76-77)

“In order for students to be motivated to engage in the behaviors that result in learning, they must believe that there is a connection between those behaviors and the outcomes they desire.” In short, positive outcome expectancies are necessary for motivated behavior. (Ambrose, et. al., pg 77)

Efficacy reflects a belief that one is *capable* of identifying, organizing, initiating, and executing a course of action that will bring about a desired outcome.” (Bandura, 1997) This is another critical dependency for motivation.

The key insight that Ambrose, et. al. draw out here is: “It is the belief in personal agency that is the potent feature of this expectancy variable that drives motivation.”

Relating this notion of “expectancy” to our earlier discussion about novices’ sparse networks of knowledge, when a novice becomes overwhelmed by the nature of wicked problems and is unable to leverage relevant strategies for navigating this complexity, s/he will soon experience negative outcome expectancy and motivation will wane. This along with the concept of “efficacy” further supports the need to provide the novice with an expert model to guide his/her practice as s/he works towards mastery. Wonder plays this role of modeling expert practice by inserting an explicit quest and feedback loop that guides further exploration and iteration.

What is now clear is that motivation has many highly sensitized interdependent parts. It is not simple, but we are now able to identify levers and controls we can use to help drive the novice’s behaviors/practice. It is here that I would like to bring in a brief, yet significant nod to the research on play and the design of games and relate it to the context of learning in order to explore possible affordances of those controls.

What is it about game design that keeps players motivated for hours on end?

Up until now, we really haven’t directly referenced “play” and I think now is the time. I’ll begin with a word from Jane McGonigal, author of *Reality is Broken: How Games Make Us Better and How They Can Change The World*: “Even when players fail, they experience intense optimistic engagement with the world.” Here, we will investigate why this is.

“...gamers believe they have every chance of success when they sit down to play a new game. Justifiable optimism is built right in to the medium. By design, every computer and video game puzzle is meant to be solvable, every mission accomplishable, and every level passable by a gamer with enough time and motivation. “... without positive failure feedback, this belief is easily undermined. If failure feels random or passive, we lose our sense of agency – and optimism goes down the drain.” (McGonigal, pg 67)

With this in mind, in Table 4 we compare motivational aspects of players versus learners and potentially identify a few triggers for interaction and sustained action. The goal of this is not to expose an exhaustive list of motivation strategies, but rather to do enough of a sampling so as to bubble up a few key themes, indicators, or differentiators. Notice that from an “expectancy” standpoint, that “players remain optimistically engaged even when they fail” seems almost certainly not the case for learners.

Motivation weight	Players	Learners
Expectancy	Games are designed for success – there is a way to win built into the game; every level is passable by a player with enough time and motivation. (McGonigal)	Courses are designed/taught with success in mind; but success/learning is not always immediately easily observable. Time for successful completion is typically predetermined by an educational institution (e.g. limited to a semester), rather than self-defined.
	Players are optimistic and believe they can win; even when they fail, they remain optimistically engaged. (McGonigal)	Learners are optimistic when they have expectancy for success. This expectancy however is highly dependent on many factors including one’s prior successes or failures in learning. When the learner has a low expectancy for success, his/her motivation will suffer. (Ambrose, et al)
	How to play is made understandable; low barrier/easy entry to play is a critical component of successful game design. (Salen)	How to learn in a particular domain may be more or less understandable by the novice depending on many factors (e.g. as we have discussed, expert’s blind spot can be at play where the component parts of developing expertise are not visible to the novice).
Agency	Players have high degree of agency (through choice, to play or not to play, who to play with, one’s own identity in the game, level of challenge, etc. Pathways through the game are made available to the player at various levels of abstraction and detail. This helps the player to know where s/he is with respect to the goals, but to also offer choice towards attainment.	Learners do not always have a high degree of agency or may not know what agency they do have. Pathways to successful learning are not always clear to the learner/novice, thus the strategies they choose to use may not be the most effective for attaining the goals.
	Feedback is immediate, frequent, and highly sensory. (McGonigal) A history of one’s moves are in many gaming environments stored and visualized (online, on paper, or in the minds of the players) and leveraged (through the rules of play) for providing the player with choices for how they want to continue through the game.	Feedback in learning is not always immediate or timely and typically not highly sensory. For example, feedback may occur 3 weeks after submitting a written assignment and come in the form of additional written text. Depending on the delivery environment and type of activity, technology may offer affordances for providing more immediate feedback (e.g., online multiple choice quiz response feedback).

Goals	Providing the right level of challenge is key to motivating play.	Providing the right level of challenge is key to motivating learning. (Willingham)
	Failure is ok and is sometimes rewarded through positive failure feedback and alternate avenues for success. (McGonigal)	Failure in learning is not ok in our current culture of education and is not rewarded. Remediation may be offered as an alternative; another likely outcome is that the failing student’s instruction may end prior to his/her achieving the goals.
	Feedback for failure is designed to motivate and sustain further play.	Feedback for failure in learning is typically/traditionally punitive and labeled (F for failure); with a high potential for demotivating further learning.
	Reality is suspended in play (i.e., consequences are not real; e.g., I am not a failure if I don’t win the game this time).	Reality is not suspended in the context of traditional learning environments/school (i.e., consequences are real, e.g., what I do in learning has real consequences for my success in the world).

Table 4: A comparison between factors influencing the motivation of players versus learners. The goal of this is not to expose an exhaustive list, but rather to do enough of a sampling so as to bubble up a few key themes, indicators, or differentiators. That “players remain optimistically engaged even when they fail” seems almost certainly not the case for learners.

With this juxtaposition we can see that players have an advantage over learners from a motivation standpoint – higher expectancies for success, more agency, clear pathways and more opportunities to reach goals. A few key differences in strategies that are used to motivate players that learners do not benefit from include:

1. **Expectancy and Goals: positive responses to failure**
(and therefore influencers on risk-taking behavior).
2. **Agency and Goals: clear pathways and informed choice**
 - who to play with, when to play, what to play, level of play, etc.
 - clear pathways so player knows where s/he is with respect to the goals and choice.
3. **Goals: amount, type, and timing of feedback** that motivates and directs further action.

When activated, wonder can reconcile the motivation-level gaps between these two worlds (play and learn) with its persistent feedback loop from awe to interaction to action and renewed awe in the outcomes of meaning making. Thus, wonder may be able to play that sustaining role for learners that games provide for players.

Somewhat reciprocally, we can activate and sustain wonder via the above strategies for motivating and sustaining play (e.g. provide a conceptual big picture of a course that will provide learners with a sense of agency by knowing what they are practicing, where they are with respect to the goals, and hence choices for knowing/employing effective strategies); which in turn engages and sustains learners in learning (i.e., the novice develops expertise by engaging the expert’s practice of active wondering).

How do we sustain the novice’s ability to wonder? We will need to align this goal (and intended outcome: expert practice) with activities that a.) offer the right level of challenge, b.) support a positive expectancy outcome, and c.) students will value (and therefore engage in).

What is now clear is that motivation has many highly sensitized interdependent parts. And with those parts, we have levers and controls. So with this in mind, again we ask:

- How can Evan be helped to achieve the learning goals?
- How can we motivate Evan to stay on path?
- How do we help Evan to value active wondering and develop expert-level design processes?

Let’s diagnose what’s happening with Evan. Given the persona description on pages 32-33, we can infer several things, including...

1. *Evan will need to ramp up on design methods used in this course.*
Given most, if not all, students in this course have not previously used these methods Evan is on a level playing field. Providing a conceptual big picture of the course may help to indicate when, where, and for what purpose various methods might be effective.
2. *We might be able to leverage Evan’s early enthusiasm in the semester.*
Through a few low-stakes practice activities that provide early opportunities for success, we might be able to sustain his motivation.
3. *Evan values the “human experience” and we may or may not be able to connect this to the course content and activities directly.*
Either way, Evan will need guidance to productively manage this driving value and effectively tie it to his efforts. Again a conceptual big picture of the course may help to align his attention and efforts with the goals of the course.
4. *Evan is not actively, concretely representing his knowledge and will need to change his behavior to achieve the learning goals.*
Evan will need practice with the component skills of representing his knowledge. Perhaps points might be associated with this to emphasize the value and need to develop this skill.

Further diagnosis and application of the learning principle for motivation:

What might we do to support Evan? Here are a few thoughts and possible strategies that branch from what we’ve discussed about motivation.

1. Provide an early low-stakes focal self-reflection activity (e.g., Why are you here and not someplace else?) to get him to:
 - a) identify his reasons for being in the course.
 - b) practice evaluating and representing his thinking on day one.
We might provide Evan with feedback on his reflection, to highlight (mis)alignments between his goals and those of the course to set his expectations (not to be confused with expectancy for success, see #2).
2. Provide scaffolding early on to focus his efforts and practice with new design methods.
When we look to the learning objectives we identified on page 22, we will see a list that builds from lesser to increasingly more complexity. This is intended to increase expectancy for success by providing scaffolded activities early on and releasing scaffolding as students become more adept. The first bullet point is an activity that uses one information resource

(though a dense one), with specific prompts. This is set up intentionally as a discrete task that offers the potential to accomplish a few important goals:

- a) Exposure to new information and ways to organize and record it for later retrieval.
 - b) Exposure to new design methods and a venue for self-explanation and representing one’s own understanding.
 - c) An opportunity for early success.
 - d) An opportunity for feedback from instructors to further guide students’ thinking.
3. Provide Evan with a conceptual big picture of the course to help him make connections and guide his activity.

A conceptual big picture of the Design the Future course to help students make connections and guide and focus their activity.

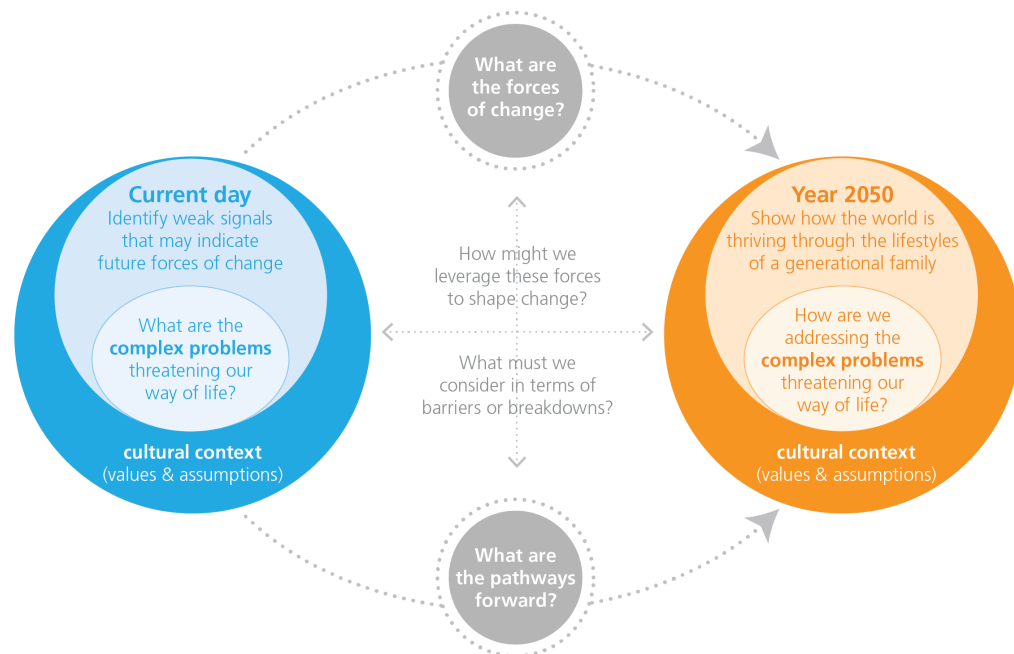


Figure 19: Students should be able to see/identify where they are and what they are doing at any point in their learning. Here I have developed a conceptual big picture of the DTF course to provide novices with a high level view or map of the concepts, with relational linkages and guiding questions. This type of view combined with the student-centered learning objectives and evaluation criteria should provide students with sufficient **agency** in knowing what they are doing (e.g. if the activities they are engaged in are well-aligned with the goals), and the degree to which they are succeeding.

4. Personalize the learning through targeted feedback to acknowledge what Evan is doing well and areas for improvement. Regular targeted feedback will help to support Evan where he is at in his learning, continually nudging him toward the intended learning goals, increasing and decreasing scaffolding as necessary. Furthermore, since we know early on that Evan has a specific driving value, we may find ways to leverage this; however if it falls outside of scope, at a minimum we can encourage him to create an explicit “parking lot” for these types of ideas. This acknowledges its importance to Evan and keeps these values front and center providing opportunities for him to make new connections and/or evolve his thinking altogether.

“Thus wonder may pass into the various forms of symbolic expression, myth, art, science, etc. – and so far as the latter retain and renew the excitement and curiosity of wonder, they perpetuate the experience of wonder itself.” (Parsons, pg 89)

Summary

We have just discussed motivation in some depth. We have found it to be a key factor that will drive one’s willingness, ability, and capacity to wonder. We now understand that learning objectives are not just critical to wonder generally, but to that upon which wonder depends: motivation. Even though we have identified the learning objectives as the map for active wondering, we understand that perceived value plays an important role. If students do not see value they will not engage in the behaviors that will produce the outcomes we envision for them. We can adjust the “intensity” for active wondering and meaning seeking, by understanding the various subjective values that students have and by designing on-switches (i.e. attainment, utility or extrinsic, and intrinsic values) into our wonder activities. Furthermore, students must have positive outcome expectancies or they will not engage. They need to know they are capable of doing the work and therefore the right level of challenge is critical. And finally, students must be able to see the connections between the actions they take and the outcomes they desire. Providing a conceptual big picture of the course helps to provide high level connections and guide their activity, providing additional agency in aligning their efforts with the goals of the course.

With the information in hand, we can now refine a general framework for wonder and discuss observations and key findings from how this played out in two additional studies with students.

Chapter 3: A Framework for Wonder

Overview

We have found from observing wonder in the field that in experiencing wonder, we can be jolted out of our everyday. We have identified barriers to active wondering as well as strategies for reducing those barriers. We have discovered that through the alignment of learning objectives with desired outcomes and activities that model expert thinking and processes we can promote active wondering.

Why do we care? As we have discussed, active wondering is what design experts do to navigate, represent, and design solutions for wicked problems and long time-horizon futures. Because novices have sparse knowledge networks, active wondering is an efficient and effective way to make new connections and create new meaning.

Experience, Interaction, Action

Here I revisit our three components of wonder: experience, interaction, and action. We saw from our classroom observations that “wonder as experience” (i.e. affective, passive, receptive) was present but did not transfer to students making connections with the concepts in the course. Therefore, there is an explicit portion of the framework aimed at getting students to actively notice and reflect: wonder as interaction. This noticing and reflection is what feeds the individual’s capacity for asking focal questions that can drive a quest for learning (i.e. wonder as action or active wondering) and the persistent, iterative cycle of inquiry. (Figure 20)



Figure 20: A framework for wonder.

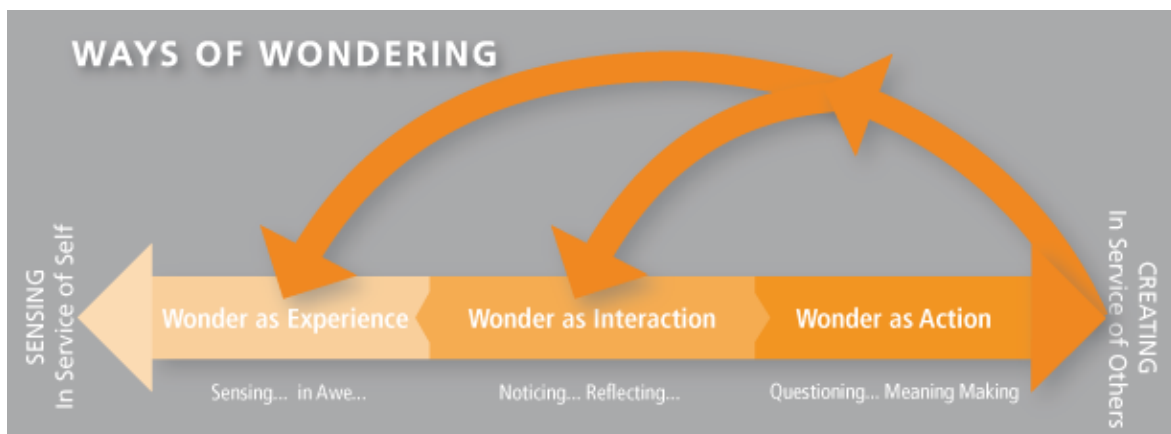


Figure 21: During active wondering, as the individual makes meaning, there is the opportunity to project that outward, and again to experience awe, as well as to notice and reflect and question further.

We can now use a framework for wonder as a structure from which to build relevant and right-leveled activities aimed at targeting the development of novices’ metacognitive skills and strengthening their design processes.

As a means to observe students’ thinking and processes, I conducted two separate studies with students focused on “wonder for interaction” and “wonder for action.”

- Study 1: Exploring wonder strategies in the context of learning with design masters students
- Study 2: Implementing wonder activities in the context of learning with undergraduate students

Study 1: Exploring wonder strategies in the context of learning with design masters students

Overview

The goal of this study was to learn more about students design thinking and processes and to see to what degree would they engage in active wondering as an integral part of their process and again to see where are the barriers.

Method: participatory session with 6 masters-level design students

A participatory session where participants engaged in 3 short activities:

1. A knowledge-building activity (10 min). Participants were provided with a reading (e.g. an aspect of e-learning). Working individually, each participant was to identify/highlight ideas presented in the article that signal something about the current state and indicate something about a possible future. Participants were provided with post-its to write down what they thought the ideas they highlighted tell us about current state, future state, and challenges. We then debriefed/discussed their ideas and their metacognitive approaches to working through the activity.
2. A brainstorming activity (10 min). Using the whiteboard and referencing the content and notes from their previous activity, participants were to imagine, list, draw out the features of a desired future state (e.g. of e-learning).
3. A reflection activity (10 min). Participants were asked to respond to several questions about their approach to this activity, including what salient features of the type of problem the activity content presented, the role of designer, and challenges they encountered.

Key findings:

1. *Students explained their thinking and process strategies in terms of general design methods.* When asked what strategies they would use to work through the activity, all students listed several human-centered design research methods including, literature review, first-hand exploratory research, identify stakeholders, create a territory map, broad inventory of the landscape, identify key problem areas, generate ideas, prototype, user test, create a business plan, and communicate out about it and market it. In addition to the standard, generic responses, one student listed “confirm the signal” (referring back to the activity instructions regarding highlighting a “signal” that tells us something about the current state.

I think it bears asking, how might an expert approach this activity? Given what we’ve discovered about expert thinking and processes, I could imagine the expert questioning, reframing the problem and drawing it out, rather laying out a list of methods to choose from. The above behavior seems consistent with what we discussed earlier about the differences between experts and novices where novices tend to use general approaches to abstract understanding in contrast to the interrogative nature of the expert’s practice.

2. *The work product focused more on representing solutions than problems or questions.* These themes emerged as future state: peer assessment, free education and credentialing, non-traditional students, better online education beyond multiple-choice questions.
3. *The target solutions envisioned did not span beyond 0-5 years.* It seemed their approach constrained, stalled their ability to envision much beyond short time horizons, but perhaps

we might also look to the human-centered design methods employed and again posit that perhaps these are not sufficient for addressing long time horizon problems.

Listening to students’ perspectives

As part of this study, I asked students several questions about the challenges and opportunities they experience with respect to solving for wicked problems. I found that the designers I spoke to were motivated to work on these types of problems seeing them as good challenges; they identified the value that designers add to these contexts; but they were also cautiously aware that there was a high learning curve. Here are a few representative responses from these interviews.

Q: What are the challenges you face designing for wicked problems?

A: For me, right now it is that I’m a novice. The learning curve is so high you immediately think, “Oh, I should have done this or that.” Like, going out there and not asking the most valuable insightful question and potentially missing that opportunity. You want nine lives for this. – CMU Design Masters-level student

Q: What excites you about designing for wicked problems?

A: Small victories become very exciting. You get to a point where it’s so complex that you feel you can’t offer anything. Then you find something small, and it’s meaningful.
– CMU Design Masters-level student

Q: What’s the role of designer in addressing wicked problems?

A: Contribute to the paradigm shift, because designers can think creatively and for any paradigm shift you need someone to say what others haven’t thought of, or have but eliminate it because it’s not “possible.” – CMU Design Masters-level student

The goals of the study were met because I gained two significant insights:

1. These designers were motivated to engage wicked problems.
2. These designers expressed a high degree of self-efficacy (i.e. belief in one’s capability) while acknowledging that they as novices face big challenges in dealing with wicked problems.

Now I wanted to find out more about specific barriers to ideating (i.e., active wondering).

What haven’t we identified as barriers?

I consulted additional research literature to find insights to helping students with idea generation and was pointed to a study by Daly, et al. The study showed (confirmed) that students tend to generate few ideas and quickly narrow down to one. When students are provided with heuristics, they generate not only more ideas, but more diverse ideas (which is also good for innovation). The types of heuristics Daly, et al. used helped students to look beyond their everyday (e.g. turn this part upside down and marry it with this unrelated part). In this sense, it implicitly moves them to question (What if? – or - If I do this, then that?). While this study was conducted with engineering students, the first part, generating few ideas and narrowing down quickly seemed consistent with the results from both my classroom observations with primarily undergraduate students and the design session I ran with masters-level students.

Design heuristics clicked as an opportunity for helping students to engage active wondering. I developed some concepts and evaluated those with students (i.e., the user testing study with undergraduate students).

Concept Generation

I designed a series of activities aimed at helping students to actively wonder. These activities leverage principles of learning (Ambrose, et al.) in that I am providing scaffolding to help guide students thinking (e.g. expert models, prompts/heuristics). I also leverage the Constructivist theory of learning (Tobias, et al.) in that this approach provides students with the opportunity to explore/play with the material prior to diving into the deep end of the wicked problems space. I also build students’ metacognitive skills by explicitly asking them to reflect on what they know and on how their thinking may have changed as a result of engaging in these activities.

Study 2: Implementing wonder activities in the context of learning with undergraduate students

Activities designed to enact active wondering...

Through a series of activities designed to engage students in active wondering, students can ramp up quickly with new methods for design and hone their metacognitive skills in preparation to engage the hard stuff – wicked problems!

Pre-activity understanding checkpoint... What do you think is involved in designing for the year 2050?

Activity Part A: Read Arnold Wasseman's "Lean 2050" future scenario. Indicate the given and what would have to change to get to a more desirable future. Select one concrete example and indicate the milestones/pathway forward. Use these two tools to respond to the respective questions.

Activity Part B: Read NY Times article about current state of MOOC's and relate this current state to a desirable future. Use these two tools to respond to the respective questions.

Post-activity understanding checkpoint... What do you think is involved in designing for the year 2050? What, if anything, has changed your thinking?

What do you know you don't know?

Figure 22: Activities designed to enact active wondering Overview

Here I am using the framework of wonder to:

1. help novices’ understand a new area of design (e.g. long time horizons);
2. get students quickly up to speed with new design methods;
3. to provide practice with expert thinking and processes (i.e. active wondering).

Method: User testing with 6 undergraduate students

During a voluntary think-aloud user testing session, 6 participants were presented with 2 activities. Each activity had a reading and two heuristic tools that I had designed for students to use to question and think through the concepts. There was a pre- and a post-activity understanding checkpoint where the same question was posed: “What do you think is involved in designing for the year 2050?” This would provide a measure of sorts to see how the activities changed/evolved the individual’s original thinking. Additionally, a metacognitive exercise was inserted between Activity A and B (i.e., “What do you know you don’t know?”)

Below are each of the activities and tools:

Beginning of session: *What do you think is involved in designing for the year 2050?*

Activity Part A: Read Arnold Wasserman’s “Learn 2050” future scenario. Indicate the givens and what would have to change to get to a more desirable future. Select one concrete example and indicate the milestones/pathway forward. Use these two tools (#1 and #2) to respond to the respective questions.

What are the “givens” that we’d have to change in order to increase the likelihood of more desirable futures happening?
DESIGN SPECULATION

1

What’s already in place?

CURRENT STATE

FUTURE PREFERRABLE STATE

What needs to change?

Where we are today and where we are in a future scenario?

2

Where are we today?

WHAT’S THE PATHWAY FORWARD?

Where are we in the future scenario?

→ Practice building metacognitive skills... What do you know you don’t know?

Activity Part B: Read NY Times article about current state of MOOCs and relate this current state to a desirable future. Use these two tools to respond to the respective questions.

What kinds of futures do people want?

3

What is likely to happen?
PROBABLE

What could happen?
PLAUSIBLE

PREFERRABLE
for whom?
who decides?

What would need to change?
POSSIBLE

Adapted from: Dunne, Anthony, and Raby, Fiona. *Speculative Everything: Design, Fiction, and Social Dreaming*. Cambridge: The MIT Press, 2013. Print. (2 - 5; ch. 1)

How is the student's day different in the future?
REIMAGINE A DAY IN THE LIFE

4

→ Practice building metacognitive skills... What do you know you don't know?

End of session: What do you think is involved in designing for the year 2050?

Key Findings:

When first asked “What do you think is involved in designing for the year 2050?”, as you might expect, the students’ responses revealed there were various interpretations of what that question meant. Some students started off by describing a future state (e.g. more plants, better technology, lots of people, space) mixed with vague processes (e.g. plans for the future, predicting future patterns). One student had an insight to not only “look at the present”, but to also “see what the consequences of our actions are.” This student had a big caveat however: “Since it is so far away, this is nearly impossible.” Another student responded “surveying large varieties of different groups of people to determine what sorts of needs are not currently being met” and hypothesized: “I think work needs to be done to level the playing field.” And another student notably had a pretty solid foundation upon which to build including, “Estimates for how long certain technologies would take to develop; Trying to decide if current trends will continue into the future; Some idea of how changing social mores might affect or fail to affect progress.”

Key insights I gained from this research activity included:

1. *There were significant shifts in thinking from the pre-activity question to the post-activity question.* One student changed his position after listening to another student debrief at the end of the session about how we could think about how we want to use technology in the future and then create the pathways to move towards that desirable future state.
Note: in response to the pre-activity question, the student debriefing had described a future state rather than a process; whereas here at the end of the session, she is describing a process.
2. *Students’ interpretations of and approaches to the activities were quite varied.* In fact, I easily generated some personas on the fly as a result: “the literal” who tells it like it is; “the analyzer” who identifies trends, patterns; “the visionary” who can make the imaginative leap.
3. *It is very much worth noting that the amount of exposure to practice in such a short period of time is another big take away – 1hr 15 min, 3 people, 2 dense readings, 4 activities, 4 questions, 1:1 debriefs.*

Key findings indicating a degree of success:

- 5 out of 5 students reported the tools helped with the readings: “helped to focus my attention (and make mental notes).”
- Post-activity understanding was improved, leveled: 2 students moved towards a more robust definition; 1 student reported he changed his definition after listening to other students’ responses; 1 student adjusted her thinking with regards to process (e.g. surveying needs was expanded to include the methods used in the activity, favoring slightly #1 and #4); and 1 student had a good definition in the pre-assessment.

Conclusion for further testing:

- Targeted activities designed to engage students in active wondering through the use of heuristics to guide their practice provide sufficient scaffolding to help students come up to speed quickly with understanding and productively using new design methods.

Representative feedback specific to the ease of use of the tools

(numbers correspond to tools above):

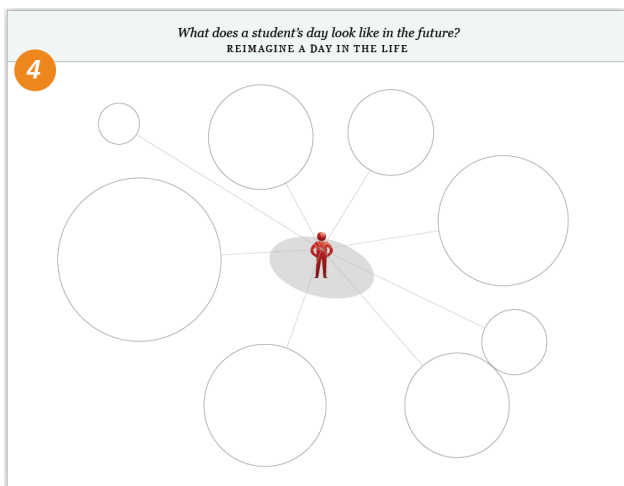
1. Hard to distinguish between “Current State” and “What’s already in place.”
2. Worked well, got it! But need more room to write.”
3. Questions clear, but difficulty distinguishing the difference between possible, probable, and plausible.
4. “This linear representation does not work because the day in the life of a future student is not routine.”

Iterative refinement based on user testing feedback

3. I had to go back to several sources to address the confusions regarding “possible, plausible, preferable” and you can see that I’ve made some adjustments with both the visual representation and the wording of the questions. This is again a derivative from (Raby, et al):



4. You can see here how I’ve attempted to directly respond to the user’s need for different visualizations for imagining a day in the life of a future student. This one shifts from the more strictly linear time-based model of a day in the life to an activity- or interest-level or amount of engagement-based model. Note: I would be adding this model to the options for representing a day in the life, rather than replacing out one for the other, as these each may provide value at different phases in the design process/thinking.



Summary

Through the use of tools, like those I have discussed above, that help novices to practice expert thinking and processes, we can help novices get up to speed quickly with new design methods; as well as to support integration of active wondering into their design processes. Using tools like these, we could have moved each of our persona types further towards expertise.

- We could have helped **Evan** to articulate and re-evaluate his assumptions. Through the use of skill-building tools like those above, we could have provided Evan with the right level of challenge with opportunities for early success. Practice with these tools could have provided sufficient scaffolding to get him up to speed quickly with new methods, as well as build routine metacognitive processes aimed at helping him to identify his information needs, thus filtering information based on self-determined gaps related to the project at hand.
- **All of our persona types** would have been better situated (having had some practice) to make their initial wonder experience (i.e., CREATE Lab visit) connected to their learning/coursework through the use of concrete heuristics to guide them in making the appropriate connections.
- We could have helped **David** and **Kim** to be more active in their exploration and openness to the discomfort of working in the wicked problem space by providing them with early, staged practice with new methods, with prompts to help guide and scope their work.
- **All personas** would have had the scaffolding to think further into the future, to extract the human values and to create more imaginative and yet concrete “future” scenarios.
- **Priscilla** could have benefited by not declining new practices and risking-taking late in the semester. While she was open and active, she occasionally closed down her “will to wonder.” We could have helped her to sustain and try new things by not only addressing her subjective value, but by offering the appropriate scaffolding just-in-time.

Future work...

1. Create an online module:

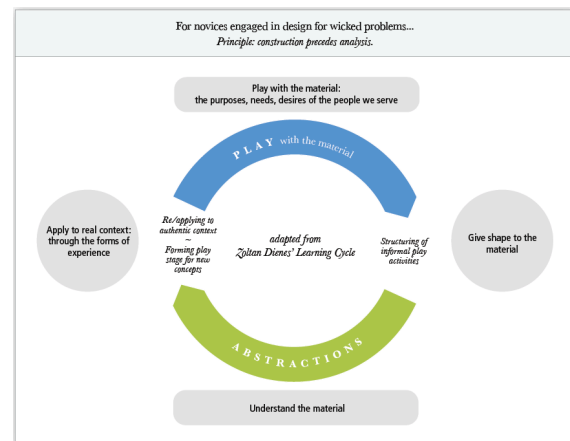
Wondering Concretely: Practice with designing for long time horizon futures

I have begun to articulate a few of design guidelines for the development of an online learning module aimed at providing students with the scaffolding and practice necessary for incorporating active wondering into their design practice. These design guidelines include...

- Students have limited time and cognitive resources, therefore edit out extraneous content. Stay narrowly focused on: “What is it they need to attend to?” Supplementary content is fine, but should not be intermixed with core content, rather it can be situated within an “explore further” type of context.
- Focusing students’ attention requires specificity (address expert’s blind spot). For example, when providing prompt questions for readings, make these prompts specific to the features you want students to pay attention to: DO NOT ASK: What are the three most important points? (What does important mean? To whom?) DO ASK: In the WBCSD report, 3 specific forces are mentioned. What are those forces and how are they influencing the future preferred state?
- Construction precedes analysis. Provide students with a way to play with the material prior to jumping into the deep end of the wicked problem space.

2. Leverage the Constructivist theory of learning:

I still want to dive into the deep end of the details around converting the constructivist theory to action for wondering, hence learning. I would like to explore ways to leverage this theory as part of developing the above online learning module.



<http://www.zoltandienes.com/academic-articles/zoltan-dienes-six-stage-theory-of-learning-mathematics/>

3. Revisit game design and play to explore strategies that might work for wonder, developing metacognitive skills, and managing motivation.

While I’ve made connections from strategies of play to motivation for learning, there’s still further study I’d like to do to draw upon the design strategies from this domain for making concrete connections to active wondering and developing expertise.

- As a subpart of this exploration, I would like to develop a “**motivation meter**” for wonder/learning. I envision a way for faculty to anticipate a motivation curve in their courses where they can plan for implementing strategies for managing this; and for students to see their level of motivation across their learning and again leverage strategies for managing this.

Conclusion

Through this study of the differences in **organization of knowledge** and design processes between **experts and novices** (*Introduction*); our exploration of **wonder**: what it is and how it works by observing it in the field and in a design studio classroom (*Chapter 1*); our insights gained about **motivation** in the context of **learning** and **play** (*Chapter 2*), we have been able to develop a **framework for wonder** (*Chapter 3*). We then explored this framework in two sample participatory and user studies with masters and undergraduate students and have identified a few key areas where a framework for wonder promotes: a.) unpacking expert processes thereby making these explicit/accessible to novices; b.) designing student-centered learning with flexible scaffolding to address students’ motivational ebbs and flows as they develop expertise; c.) increasing agency by triggering the novice’s capacity for wonder and extending that through a frame that focuses attention and directs and sustains effort.

We have found from observing wonder in the field that in experiencing wonder, we can be jolted out of our everyday. We have identified barriers to active wondering as well as strategies for reducing those barriers. We have discovered that through the alignment of learning objectives with desired outcomes and activities that model expert thinking and processes we can promote active wondering. We put forth that the power of these individual strategies becomes more obvious when packaged together (page 55-56):

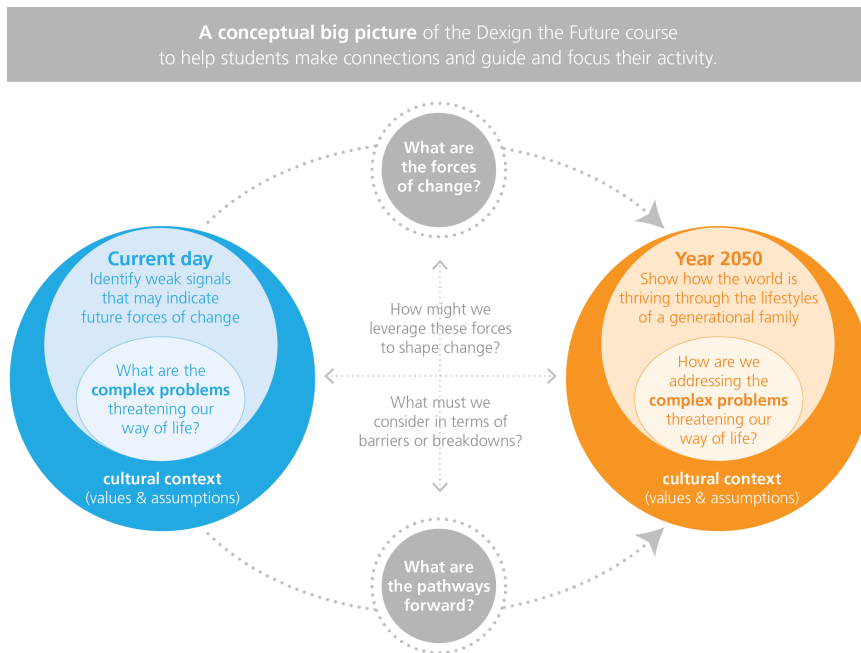
- **A map:** the conceptual big picture
- **A compass:** student centered learning objectives
- **A destination:** evaluation criteria
- **Self-efficacy:** Opportunities for early success through guided practice w/feedback

This learning package, containing outcomes from our previous explorations and trials, provides salient framing, key conceptual connections, and actions that a novice could both understand and leverage to build new knowledge and direct their own learning via expert models of practice.

Acknowledging, of course, that this package is short of a full course design; but indicating the weight of these elements for supporting novices to wonder their way into deep learning.

Repackaging “Design the Future”: Leveraging a framework for wonder

A conceptual big picture: a map for wayfinding and a structure for building new knowledge.



Learning Objectives (LO): the “compass” that guides and directs purposeful, active wondering.

1. Describe the global forces of change in 2050 as identified by the WBCSD (information provided on the course website).
2. Identify and describe the forces of change in Pittsburgh 2050, drawing from the global forces, additional information provided on the course website, plus data you gather from local field studies.
3. Identify 5 themes (e.g. sustainability, economic equality, access to education) that have emerged from the information and data you are choosing to use.
4. Define the top 5 most influential institutions, policies, and aspects of material culture shaped by these forces.
5. Create future scenario concepts expressed through the lifestyles of a generational family that integrate the forces of change you identified and relate the institutions, policies, and material culture of Pittsburgh 2050 with those forces and other relevant findings from your research.
6. Reflect and question to develop new understanding: at each step throughout your process, create self-explanations about what you know and list questions you have about what you don’t know; and the relevant sources you might consult to find answers.

Evaluation Criteria (sample/subset): a measure to assess level of achievement/success.

Criteria (source: DTF syllabus)	Levels of achievement		
1. Connection to research	Sophisticated	Competent	Not Yet Competent
LO5: Create future scenario concepts...	Deep and logical connection between research and concept directions developed.	Some connections to research conducted, but other important findings are not addressed.	Little or no connection to the research conducted

Practice with new methods: a means for self-efficacy and skills that transfer to new contexts

Through the use of tools and scaffolded activities, like those I have discussed in study 2 (page 47-49) that help novices to practice expert thinking and processes, we can help novices get up to speed quickly with new design methods; as well as to support integration of active wondering into their design processes.

Activities designed to enact active wondering...

Through a series of activities designed to engage students in active wondering, students can ramp up quickly with new methods for design and hone their metacognitive skills in preparation to engage the hard stuff – wicked problems!

2 novices with credit at CMU had engaged with students
Both novices indicated wonder, a variety of design, and a variety of thinking
Both novices had experience with active and reflective practice

Pre-activity understanding checkpoint... What do you think is involved in designing for the year 2050?

Activity Part A: Read Arnold Weissenberg's "Urban 2050" future scenario. Indicate the goals and what would have to change to get to a more desirable future. Select one concrete example and indicate the relationship/gateway forward. Use these two tools to respond to the respective questions.

Activity Part B: Read NY Times article about current state of MOOCs and relate this current state to a desirable future. Use these two tools to respond to the respective questions.

What do you know you don't know?

Post-activity understanding checkpoint... What do you think is involved in designing for the year 2050? What, if anything, has changed your thinking?

With this repackaging, we are attempting to provide novices with low barriers to entry and clear pathways to success which incorporate mechanisms for knowing where they are in their learning, how far off the target is, what success looks like, as well as activities to build efficacy; together providing a great degree of agency. We are not meaning to suggest however that we are removing challenges necessary for building robust learning – quite the contrary. By providing tools for building expertise, by making expert processes explicit, and by providing novices with strategies for “seeing their own cognitive moves” and filling information gaps (through active wondering), we provide them with strategies for building new connections, for developing their own pattern recognitions and information filters; thus building many “roads” for access, later retrieval, and transfer – transfer from one context to another. As novices develop expertise, their active wondering processes provide a feedback loop for sustaining their exploration, meaning making, creation-evaluation iterative processes, at times leading to revisiting wondering in awe at the creations themselves.

Summary:

Driving questions around wonder and its role for learning, guide the work of this thesis. I developed a framework of wonder and explored how students might get up to speed quickly with new design methods using a series of learning activities I designed with the intent to scaffold students’ practice and intersperse explicit metacognitive reflective practice. While it is within the context of higher education, and more specifically transition design education, in which I have situated and practiced with the role of wonder for learning, one could extend the general framework to other contexts where learners are required to stretch well beyond their current frames, to imagine the unimaginable, to snap out of their everyday, to notice what has become invisible, to build new understanding, and to reflect on the consequences of actions they have not yet taken. At this point in our exploratory journey we have new questions to ask and other research methods to draw upon to test this model and iterate on solutions that might support students to wonder their way into deep learning.

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<http://ixdcourse.com/>

School of Design, Carnegie Mellon University

<http://design.cmu.edu/>

Zoltan Dienes' six-stage theory of learning mathematics:

<http://www.zoltandienes.com/academic-articles/zoltan-dienes-six-stage-theory-of-learning-mathematics/>

Appendix

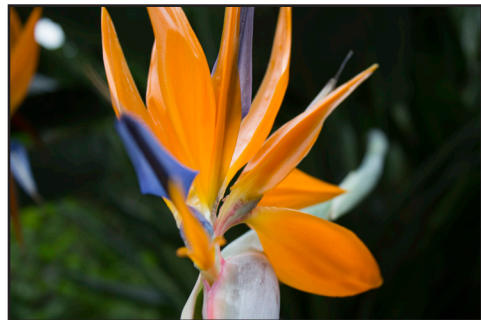
- Field study photo essay
- Research Study Protocols, Documents:
 - Participatory Design Study Protocol
 - User Testing Study Protocol
 - New York Times article: MOOCs (used in both studies)
 - DMI article: Learn 2050 (used in study#2)
- Design The Future course syllabus
- Arnold Wasserman bio
- Peter Scupelli bio

Wonder

watching webcams...

“Ever wonder how the bald eagles were reintroduced back into Pennsylvania? If so check out this video that the PA Game Commission put together.” – PixController

observing wonder in the field...
visits to the National Aviary and Phipps Conservatory



see **vibrant**



touch **spiney**



smell **stealing gardenia**



taste **tart**



hear **penguin play**



immerse yourself...

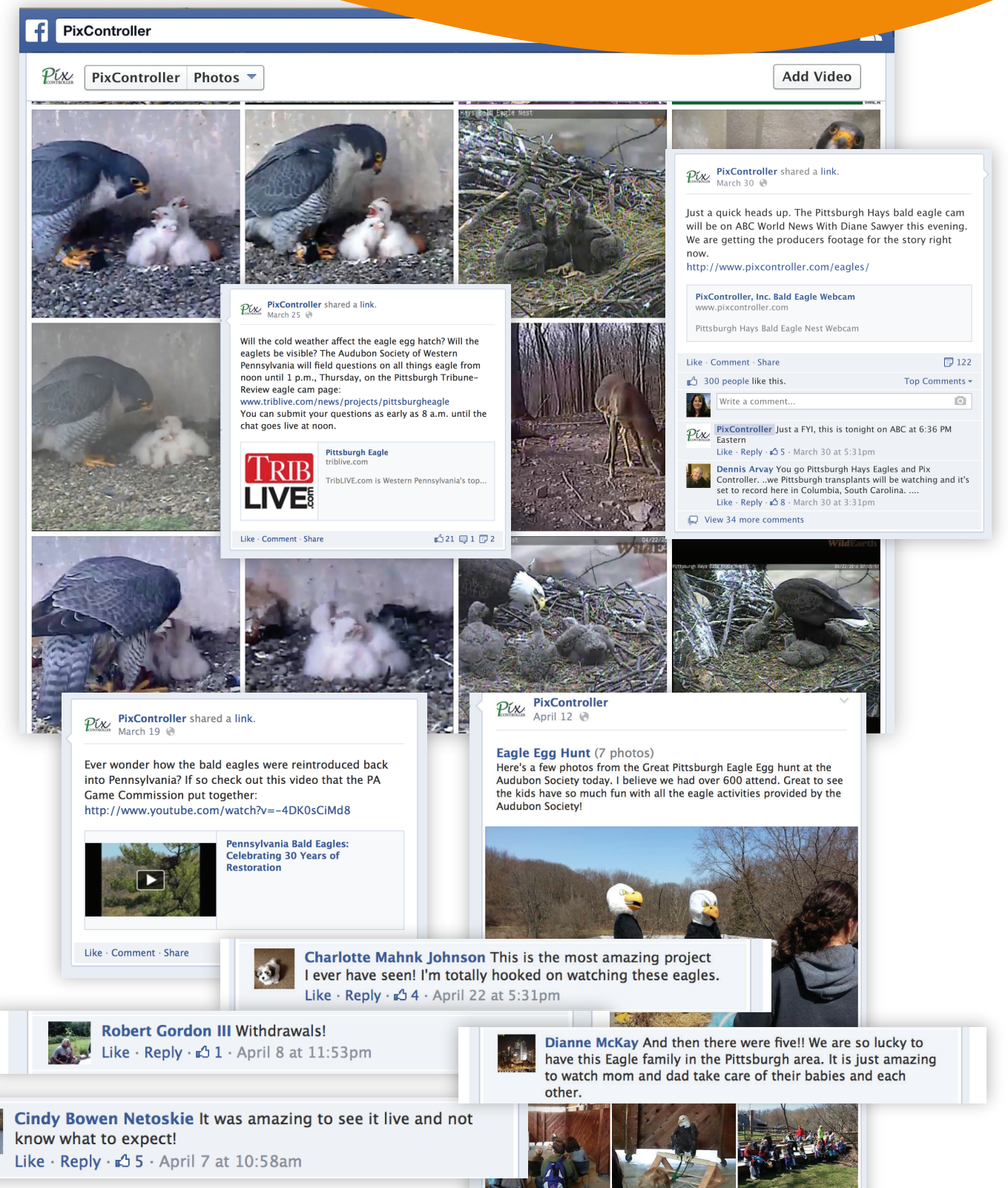


...in the experience go ahead, do it

Do people wonder differently based on the medium?

(e.g. experiencing a butterfly garden vs watching a video about butterflies)?

One might expect to experience wonder differently in person than through a web browser. However, with comments like “Withdrawals!” because the webcam went offline for a while, and “It was amazing to see it live...” when watching the eaglets hatch online, the venue through which we wonder seems to fade into the background.



2014-04-28 18:05:25

viewers: 1954

total views: 1,419,275

Working from the perspective of a design student doing this activity for class...

What do MOOCs tell us about the future of education?

1. Read this article by the New York Times, 2012.

I've highlighted a few ideas that I think may be weak signals that tell us something about the current state and signal something about possible future states.

Highlight one to three other ideas here that you think may be signals.

2. Explain the significance of one signal that you or I highlighted.

But first, using your post-its:

List out some techniques or strategies you might use to help you understand this?

- What does this tell you about the current state?
- What are the challenges this indicator signals?
- What does this signal tell you about a possible future state?

3. Let's debrief (discuss). Share your thoughts with the group.

4. Imagine a *desired* future state that you would like to create/realize.

But first, using the whiteboard:

Brainstorm a few techniques or strategies you might use to help you accomplish this?

- What does this desired future look like; what have you addressed?
- Who does this help? What are their future needs?
- What will it take to get there? What has to happen for this to become a reality?
- What are the challenges?

A. What do you think is involved in designing for the year 2050?

B. Read this Future Scenario written by a leading consultant for innovation and strategy, principal of Collective Invention working on designing for the year 2050.

1. *What are the givens in the article?*

Use the 2x2 to plot out the “givens” in the article, current state, future state, evidence and change needed.

2. *How do we get there; what needs to change?*

Use the Milestones diagram to:

- Select one thing from the article that is representative of “Current” state.
- Enter how this is changed in 2050 into the “Future”.
- Indicate forces of change and milestones along the pathway.

3. *What do you know you don’t know?*

C. Read this NY Times article about current state of MOOCs and relate this current state to a desirable future.

1. *What is a preferable future of education?*

Use the Venn Diagram to chart out responses to the questions to see what falls within the “preferable future” area.

2. *What is a day in the life?*

Lay out a “day in the life” of a future student. Create 2 vignettes:

- a. Current state of education
- b. Future state of education

3. *What do you know you don’t know?*

D. What do you think is involved in designing for the year 2050?

- What has changed your thinking?

The Year of the MOOC



Clockwise, from top left: an online course in circuits and electronics with an M.I.T. professor (edX); statistics, Stanford (Udacity); machine learning, Stanford (Coursera); organic chemistry, University of Illinois, Urbana (Coursera).

By LAURA PAPPANO
Published: November 2, 2012

IN late September, as workers applied joint compound to new office walls, hoodie-clad colleagues who had just met were working together on deadline. Film editors, code-writing interns and “edX fellows” — grad students and postdocs versed in online education — were translating videotaped lectures into MOOCs, or massive open online courses. As if anyone needed reminding, a row of aqua Post-its gave the dates the courses would “go live.”

[Go to Education Life »](#)

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[The Big Three, at a Glance](#)
(November 4, 2012)

The paint is barely dry, yet [edX](#), the nonprofit start-up from Harvard and the Massachusetts Institute of Technology, has 370,000 students this fall in its first official courses. That’s nothing. [Coursera](#), founded just last January, has reached more than 1.7 million — growing “faster than Facebook,” boasts Andrew Ng, on leave from Stanford to run his for-profit MOOC provider.

“This has caught all of us by surprise,” says David Stavens, who formed a company called [Udacity](#) with Sebastian Thrun and Michael Sokolsky after more than 150,000 signed up for Dr. Thrun’s “Introduction to Artificial Intelligence” last fall, starting the revolution that has higher education gasping. A year ago, he marvels, “we were three guys in Sebastian’s living room and now we have 40 employees full time.”

“I like to call this the year of disruption,” says Anant Agarwal, president of edX, “and the year is not over yet.”

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4. OPEN BOOK In the Eye of the Beholder

5. ARTSBEAT Book Review Podcast: A Sentimental Education

6. Letters: 'My Life in Middlemarch'

7. Three Sensational Deaths and Two Notable Lives

8. ARTSBEAT Book Covers: Before and After

9. OPINION Woody Allen Speaks Out

MOOCs have been around for a few years as collaborative techie learning events, but this is the year everyone wants in. Elite universities are partnering with Coursera at a furious pace. It now offers courses from 33 of the biggest names in postsecondary education, including Princeton, Brown, Columbia and Duke. In September, Google unleashed a MOOC-building online tool, and Stanford unveiled [Class2Go](#) with two courses.

Nick McKeown is teaching one of them, on computer networking, with Philip Levis (the one with a shock of magenta hair in the introductory video). Dr. McKeown sums up the energy of this grand experiment when he gushes, “We’re both very excited.” Casually draped over auditorium seats, the professors also acknowledge that they are not exactly sure how this MOOC stuff works.

“We are just going to see how this goes over the next few weeks,” says Dr. McKeown.

WHAT IS A MOOC ANYWAY?

Traditional online courses charge tuition, carry credit and limit enrollment to a few dozen to ensure interaction with instructors. The MOOC, on the other hand, is usually free, credit-less and, well, massive.

Because anyone with an Internet connection can enroll, faculty can’t possibly respond to students individually. So the course design — how material is presented and the interactivity — counts for a lot. As do fellow students. Classmates may lean on one another in study groups organized in their towns, in online forums or, the prickly part, for grading work.

The evolving form knits together education, entertainment (think gaming) and social networking. Unlike its antecedent, open courseware — usually written materials or videotapes of lectures that make you feel as if you’re spying on a class from the back of the room — the MOOC is a full course made with you in mind.

The medium is still the lecture. Thanks to [Khan Academy](#)’s free archive of snappy instructional videos, MOOC makers have gotten the memo on the benefit of brevity: 8 to 12 minutes is typical. Then — this is key — videos pause perhaps twice for a quiz to make sure you understand the material or, in computer programming, to let you write code. Feedback is electronic. Teaching assistants may monitor discussion boards. There may be homework and a final exam.

The MOOC certainly presents challenges. **Can learning be scaled up this much?** Grading is imperfect, especially for nontechnical subjects. Cheating is a reality. “We found groups of 20 people in a course submitting identical homework,” says David Patterson, a professor at the University of California, Berkeley, who teaches software engineering, in a tone of disbelief at such blatant copying; Udacity and edX now offer proctored exams.

Some students are also ill prepared for the university-level work. And few stick with it. “Signing up for a class is a lightweight process,” says Dr. Ng. It might take just five minutes, assuming you spend two devising a stylish user name. Only 46,000 attempted the first assignment in Dr. Ng’s course on machine learning last fall. In the end, he says, 13,000 completed the class and earned a certificate — from him, not Stanford.

That’s still a lot of students. **The shimmery hope is that free courses can bring the best education in the world to the most remote corners of the planet, help people in their careers, and expand intellectual and personal networks.** Three-quarters of those who took Dr. Patterson’s “Software as a Service” last winter on Coursera (it’s now on edX) were from outside the United States, though the opposite was true of a course on circuits and electronics piloted last spring by Dr. Agarwal. But both attracted highly educated students and both reported that over 70 percent had degrees (more than a third had graduate degrees). And in a vote of confidence in the form, students in both overwhelmingly endorsed the quality of the course: 63 percent who completed Dr. Agarwal’s course as well as a similar one on campus found the MOOC better; 36 percent found it comparable; 1 percent, worse.



10. Does a More Equal Marriage Mean Less Sex?

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Ray Schroeder, director of the [Center for Online Learning, Research and Service](#) at the University of Illinois, Springfield, says three things matter most in online learning: quality of material covered, engagement of the teacher and interaction among students. The first doesn't seem to be an issue — most professors come from elite campuses, and so far most MOOCs are in technical subjects like computer science and math, with straightforward content. But providing instructor connection and feedback, including student interactions, is trickier.

“What’s frustrating in a MOOC is the instructor is not as available because there are tens of thousands of others in the class,” Dr. Schroeder says. **How do you make the massive feel intimate?**

That’s what everyone is trying to figure out.

Many places offer MOOCs, and more will. But Coursera, Udacity and edX are defining the form as they develop their brands.

THE FLAVOR OF THE MOOC

Coursera casts itself as a “hub” — Dr. Ng’s word — for learning and networking. The learning comes gratis from an impressive roster of elites offering a wide range of courses, from computer science to philosophy to medicine. Not all are highbrow or technical; “Listening to World Music” from the University of Pennsylvania aims to broaden your playlist.

While Coursera will make suggestions, Dr. Ng says, **“ultimately all pedagogical decisions are made by the universities.”** Most offerings are adapted from existing courses: a Princeton Coursera course is a Princeton course. But the vibe is decidedly Facebook — build a profile, upload your photo — with tools for students to plan “meet-ups” with Courserians in about 1,400 cities worldwide. These gatherings may be bona fide study groups or social sessions. Membership may be many or sparse.

No one showed at the meet-up that Stacey Brown, an information technology manager at a Hartford insurance company, scheduled for a 14th-floor conference room on a Thursday after work, despite R.S.V.P.’s from a few classmates in the area. He’s taking three Coursera MOOCs, including “Gamification” from the University of Pennsylvania Wharton School. In addition to the learning — and dropping to bosses that he’s taking a Wharton course — Mr. Brown says, “I hope to get a network.”

Others like the discipline a group offers. Kimberly Spillman, a software engineer, started taking seven MOOCs and completed three. **“The ones I have study groups with people, those are the ones I finish,”** Ms. Spillman says. She first joined a group for Dr. Thrun’s artificial intelligence course, and then ran one for a Udacity course on building a search engine, organizing Thursday-evening discussions of the week’s material followed by a social hour at a nearby pub. Fifteen people met each week at the Ansir Innovation Center, a community space with big tables and comfortable chairs, in the Kearny Mesa neighborhood of San Diego.

Udacity has stuck close to its math and computer science roots and emphasizes applied learning, like “How to Build a Blog” or “Building a Web Browser.” **Job placement is part of the Udacity package.** “The type of skills taught in computer science, even at elite universities, can be very theoretical,” Dr. Stavens explains.

Udacity courses are designed and produced in-house or with companies like Google and Microsoft. In a poke at its university-based competition, Dr. Stavens says they pick instructors not because of their academic research, as universities do, but because of how they teach. “We reject about 98 percent of faculty who want to teach with us,” he says. “Just because a person is the world’s most famous economist doesn’t mean they are the best person to teach the subject.” **Dr. Stavens sees a day when MOOCs will disrupt how faculty are attracted, trained and paid, with the most popular “compensated like a TV actor or a movie actor.”** He adds that “students will want to learn from whoever is the best

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teacher.”

That means you don’t need a Ph.D. While there are traditional academics like David Evans of the University of Virginia, “[Landmarks in Physics](#),” a first-year college-level course, is taught by Andy Brown, a 2009 M.I.T. graduate with a B.S. in physics. “We think the future of education is guys like Andy Brown who produce the most fun,” Dr. Stavens says. Mr. Brown’s course is an indie version of “Bill Nye the Science Guy” — filmed in Italy, the Netherlands and England, with opening credits for “director of photography” and “second camera and editor.”

Whether explaining what the ancients believed about the shape of the earth or, in Dr. Thrun’s statistics course, why you are unpopular, statistically speaking, voice-overs are as nonthreatening as a grade school teacher.

“You feel like you are sitting next to someone and they are tutoring you,” says Jacqueline Spiegel, a mother of three from New Rochelle, N.Y., with a master’s in computer science from Columbia who has enrolled in MOOCs from Udacity and Coursera. While taking “Artificial Intelligence,” she discovered she liked puzzling through assignments in online study groups.

The class was tough and took “an embarrassing amount of time,” says Ms. Spiegel, who found that consuming lectures by smartphone during her 14-year-old’s 6 a.m. ice skating sessions worked less well than being parked at a desktop. “I would listen to the lectures, then I would listen to them again.” Her effort was huge — some 22 hours a week — but rewarding. Ms. Spiegel befriended women in India and Pakistan through Facebook study groups and started an online group, CompScisters, for women taking science and technology MOOCs.

If Udacity favors stylish hands-on instruction, edX aims to be elite, smart and rigorous; don’t expect a gloss of calculus if you need it but never took it. Some 120 institutions have been in touch; only Berkeley and the University of Texas system have been admitted to the club.

EdX’s M.I.T. roots show in its staff’s geeky passion for building and testing online tools. They collect your clicks. Feedback from the MOOC taught last spring by Dr. Agarwal (who, students learn, is obsessed with chain saws) revealed that participants would rather watch a hand writing an equation or sentence on paper than stare at the same paper with writing already on it.

The focus is on making education logical. “Someone who is consuming the course should know it is not serendipity that the course is chunked in a certain way, but that there is intentionality to sequencing video,” says Howard A. Lurie, vice president for content development.

With mini-notebook in hand, he has been leading the “daily stand-up” meeting (so called because attendees lean against walls) to keep course development on schedule. After one meeting, Lyla Fischer, a 2011 M.I.T. graduate and edX fellow, sat at her computer, a tag still dangling from the chair, and edited the answers for problem sets in Dr. Agarwal’s course. Last spring, students could download PDFs with brief answers. Now, she says, “there is a full explanation of how to do it, here are the steps,” right on the site.

“We are trying to use the magic of all the tool sets we have,” Mr. Lurie says. Students control how fast they watch lectures. Some like to go at nearly double the speed; others want to slow down and replay. Coming: If you get a wrong answer, the software figures out where you went wrong and offers a correction.

WORKING OUT THE KINKS

Assignments that can’t be scored by an automated grader are pushing MOOC providers to get creative, especially in courses that involve writing and analysis. Coursera uses peer grading: submit an assignment and five people grade it; in turn, you grade five

assignments.

But what if someone is a horrible grader?

Coursera is developing software that will flag those who assign very inaccurate grades and give their assessment less weight. Mitchell Duneier, a Princeton professor, is conducting a study that compares peer grading of the final exam in his sociology MOOC on Coursera last summer with the grades he and his course assistants would have given the students.

Mr. Brown, the Hartford I.T. manager, does not have confidence in peer feedback. “This could be a 14-year-old kid in South Africa answering me,” he says, thinking of his 14-year-old. The challenge is not just in grading. The diversity of MOOC takers — teenagers to retirees, and from across the globe — means classmates lack a common knowledge base and educational background. Out-of-their-league students, especially in highly technical courses, can drag down discussions.

Which course is right for you? What prerequisites are really needed to perform well? Princeton’s “Networks: Friends, Money and Bytes” on Coursera recommends basic linear algebra and multivariable calculus but the “instructor will see if part of the course material can be presented without requiring this mathematical background.” “Introduction to Computer Science” from Harvard lists prerequisites as “none” — as long as you’re Harvard-ready. Where are the Yelp reviews?

“We desperately need crowdsourcing,” says Cathy N. Davidson, a Duke professor of English and interdisciplinary studies. “We need a MOOCE — massive open online course evaluation.”

Most important, what do you get for your effort? Do you earn a certificate? A job interview? Or just the happy feeling of learning something?

“If one is going for the knowledge, it’s a boon,” says Dr. Schroeder of the University of Illinois. “If one is looking for credit, that is one of the challenges. How do we fit this into the structure of higher education today?”

Dr. Agarwal predicts that “a year from now, campuses will give credit for people with edX certificates.” He expects students will one day arrive on campus with MOOC credits the way they do now with Advanced Placement.

The line between online and on campus is already blurring. This spring Dr. Davidson will teach a class called “[Surprise Endings: Social Science and Literature](#)” at Duke and as a MOOC, with her Duke students running the online discussions. This fall, San Jose State students are taking Dr. Agarwal’s course on [circuits and electronics](#), with professors and teaching assistants on campus leading discussions. They add their own content, including exams. In the spring, Massachusetts Bay Community College in Wellesley will use an edX MOOC in introductory computer science.

Dr. Stavens promises more change, and more disruption: “We are only 5 to 10 percent of the way there.”

Laura Pappano is author of “Inside School Turnarounds” and writer in residence at the Wellesley Centers for Women.

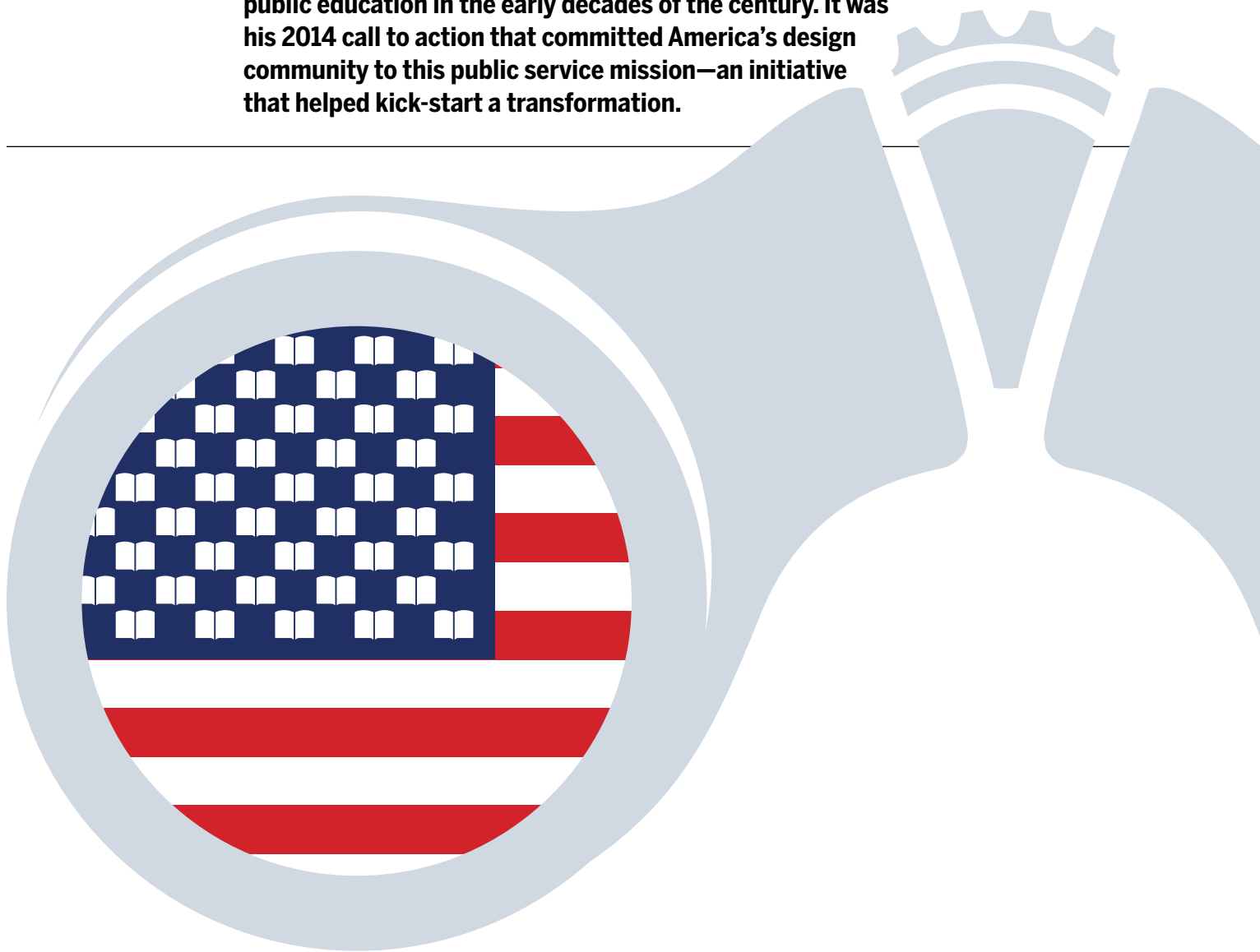
This article has been revised to reflect the following correction:

Correction: November 11, 2012

An article last Sunday about massive open online courses, using information from the MOOC provider Coursera, included several errors. The source of a study of peer grading in a Princeton sociology MOOC was Mitchell Duneier, the teacher, not Coursera. The student work was regraded by Professor Duneier and his teaching assistants, not by Princeton instructors. And it is not the case that the results have been released. The article also misspelled the surname of a co-founder of another MOOC provider, Udacity.

By Arnold
Wasserman

It's the year 2050 and this pioneer of the Redesign Learning movement is looking back on the parlous state of American public education in the early decades of the century. It was his 2014 call to action that committed America's design community to this public service mission—an initiative that helped kick-start a transformation.



LEARN! S

How We Transformed America's Learning System



2050

Alice: Would you tell me, please, which way I ought to go from here?
The Cheshire Cat: That depends a good deal on where you want to get to.

— Lewis Carroll, *Alice in Wonderland*



June 15, 2050:
My 80th birthday—marking 50 years of observing and participating in the transformation of learning.

Where are we? How did we get here?

Today's Generations Alpha and Beta cannot remember a time when all public education, from pre-school through college, wasn't *free*. They can't believe that today's public curriculum, rich not only in science, technology, engineering, and math but also the arts, design, creativity, history, language, and all the other humanities—plus exercise, sports, yoga, and meditation—was not always the norm. Were we once forced to make the binary choice—either a broad humanistic education or technical career preparation? Was there really a time when we did not apply state-of-the-art cognitive neuroscience, learning science, sociology, and electronic technology to student-centered, self-paced, creativity-based open learning?

Did students back then actually spend their entire day butts-in-a-chair at a single location? Today, learning takes place everywhere—out in the community and at cultural institutions, at fab labs, tech shops, tinker spots, arts studios, innovation hubs, and at learning incubators and accelerators. It takes place online, on-demand, and just-in-time. It is flipped, blended, and open. An American student learns in peer study groups with partners in other countries. Her e-learning coach may be anywhere in the world. Teacher-

Notes

1. National Center for Education Statistics, "Fast Facts."
2. As measured by PISA (Program for International Student Assessment). While PISA's methodology had more than a few critics, it was the best longitudinal instrument we had, dating back to 2000.
3. OECD, 2012 OECD PISA Report, United States key findings.
4. OECD, "Viewing Education in the US Through the Prism of PISA" (Chapter 2 in "Strong Performers and Successful Reformers in Education: Lessons from PISA for the United States"), 2010.
5. Bureau of Labor Statistics (BLS), *Occupational Outlook Handbook*, 2010-11.
6. Ibid.



U.S OECD RANKINGS 2010 TO 2013

READING

14

17

MATH

25

26

SCIENCE

17

21

coaches are expert at knowing which students need more scaffolded structure versus self-directed messing around—and when.

Today's students know that you don't learn by getting the right answer but by asking good questions and by failing early, fast, and often.

Little of this was true in the early 2000s.

Back then, there was a high wall of tests separating high school from college and another wall separating school from work life—unlike today, when there is seamless migration from high school to college and onward to jobs grounded in lifelong learning. When today's students hear that the average 2013 college student's debt was more than \$29,000 and totaled more than \$1 trillion dollars nationally, they ask, "What were you people thinking?"

Back in 2013, after Austria, Luxembourg, Norway, and Switzerland, the United States spent more on education than any other nation, \$12,743 per public school student per year.¹ But we got such a poor return on that investment.

American students ranked at or below the average among the 34 OECD (Organization for Economic Cooperation) member developed nations.² And America was trending lower. From 2010 to 2013, the US slipped from fourteenth to seventeenth in reading, from twenty-fifth to twenty-sixth in math, and from seventeenth to twenty-first in science.³ One reason US scores declined relative to other nations was because those nations were improving fast—and they were investing mainly in continuously raising their top achievers.

The OECD warning

One of the myriad reports issued by OECD every year was, "Viewing Education in the US Through the Prism of PISA [Program for International Student Assessment] 2010." Buried in it was a paragraph that a few of us took note of (emphasis is mine).⁴ It addressed the economic cost of America's achievement gap:

The international achievement gap is imposing on the United States economy an invisible yet recurring economic loss that is greater than the

output shortfall in what has been called the worst economic crisis since the Great Depression. Using economic modeling to relate cognitive skills—as measured by PISA and other international instruments—to economic growth shows (with some caveats) that even small improvements in the skills of a nation's labor force can have large impacts on that country's future well-being. A recent study carried out by the OECD, in collaboration with the Hoover Institute at Stanford University, suggests that a modest goal of having the United States boost its average PISA scores by 25 points over the next 20 years—which corresponds to the performance gains that some countries achieved between 2000 and 2009 alone—could imply a gain of \$41 trillion for the United States economy over the lifetime of the generation born in 2010 (as evaluated at the start of reform in terms of the real present value of future improvements in GDP). Bringing the United States up to the average performance of Finland, the best-performing education system among OECD countries, could result in gains in the order of \$103 trillion (page 38).

Leave aside whether American 15-year-olds tested as well as Finns or South Koreans, in absolute terms our human capital was lagging ever further behind resource demand. At the same time graduating students were having a hard time finding decent jobs, there were chronic job shortages in sectors like healthcare, skilled manufacturing, and technology. Students' graduating skills did not align with the jobs available; American employers had to hire skilled foreign workers or send jobs overseas. Could there be a worse misalignment between means and ends?

The Bureau of Labor Statistics projected that jobs in computer systems design and related services—a field dependent on high-level math and problem-solving skills—would grow by 45 percent between 2008 and 2018.⁵ More than one in four of all new jobs created in the US economy during that time would be in the healthcare and social assistance industry.⁶ Occupations with the fastest growth in the coming years—such as

7. 2013 SAT Report on College and Career Readiness.

9. The Stupski Foundation, internal proprietary research.

10. OECD 2010, *op. cit.*, p. 233.

8. Sarah Reckhow, *Follow the Money: How Foundation Dollars Change Public School Policies* (New York: Oxford University Press, 2013), p. 28.

biomedical engineers, network systems and data communications analysts, medical scientists, and physician's assistants—would call for baccalaureate, master's, and doctoral degrees in STEM (science, technology, engineering, and mathematics) fields.⁷

Notwithstanding all the political rhetoric about revitalizing the US economy through new job creation in fast-growing industries, far too few students would be equipped to do those jobs if we did not change course dramatically.

Not surprisingly, education mirrored America's disparities in income, opportunity, and social mobility, which, in a continuous feedback loop, were themselves in large measure caused by inequality in education. We had much broader deviation from the mean than other nations, ranging from elite college prep schools to ghetto battlegrounds. Charter schools originally intended to encourage flexibility and innovation did not, on average, perform better than public schools and, in some instances, served re-segregation by race and income. Privatization of schools—for those who could afford them—further exacerbated these trends.

The US government invested most of its public reform money to push up attainment at the bottom end of the socioeconomic scale. The same was true of the \$1 billion dollars per year spent by private educational philanthropies.⁸ While that need was unquestionably urgent, the intensity of the focus made it seem as if the bottom tier was America's whole education problem, which was not at all the case. Of the 50 million public school students in the US, approximately one million were most at risk. Of approximately 140,000 public schools in the US, there were about 1,200 that were chronic low performers, with high schools having 40 percent to 50 percent dropout rates, mainly for black and Hispanic students. About 80 percent of those schools were concentrated in five states: Arizona, New Mexico, Texas, Mississippi, and Florida.⁹ So the bottom end was not an unbounded problem space.

In 2011, OECD offered lessons from high-performing countries for establishing ambitious, focused, and coherent education standards that are shared across the system and aligned with high-stakes gateways and instructional systems:

Fifteen-year-olds in the United States often rate themselves comparatively highly in academic performance in PISA, even if they did not do well comparatively. In part, that may be due to culture, but one interpretation is also that students are being commended for work that would not be acceptable in high-performing education systems. The results from PISA suggest that, across OECD countries, schools and countries where students work in a climate characterised by high performance expectations and the readiness to invest effort, good teacher-student relations, and high teacher morale tend to achieve better results. One trend across countries over recent years has been for countries to articulate the expectations that societies have in relation to learning outcomes and to translate these expectations into educational goals and standards. All of the high-performing countries profiled in this volume have developed world-class academic standards for their students and their existence tends to be a consistent predictor for the overall performance of education systems. The approaches to standard-setting in OECD countries range from defining broad educational goals up to formulating concise performance expectations in well-defined subject areas. Whatever the approach, such standards shape high-performing education systems by establishing rigorous, focused and coherent content at all grade levels; reducing overlap in curricula across grades; reducing variation in implemented curricula across classrooms; facilitating co-ordination of various policy drivers, ranging from curricula to teacher training; and reducing inequity in curricula across socio-economic groups.¹⁰

America was unable to think strategically about education—to align learning with long-horizon social and economic goals, create policies, commit resources, and sustain programs beyond the two-year election cycle.

Notes

11. Ken Robinson, TED Talk, 2010.

12. SAT Report, *op. cit.*

Reforming educational reform
“Reform is no use anymore, because
that’s simply improving a broken model.
What we need...is not evolution, but
a revolution in education. It has to
be transformed into something else.”

Sir Ken Robinson¹¹

This 2010 quote summed up the inadequacy of the term *reform* to capture what had to happen to education in America.

In practice, top-down school reform had mainly perverse effects. It became a cover-your-ass game of tests, inducements, performance measures, and punishments ensuring that when things went wrong, teachers—who were at the sharp point of the process—would be to blame. No Child Left Behind became No Teacher Left Standing. Race to the Top was Race Sideways. While Common Core had the merit of coordinating outcome assessment across states in math and language arts, neither it nor any other reforms seriously addressed the meta-cognitive capacities required to succeed in an exponential world—that is, learning to learn, knowledge about knowledge, adaptive creativity, mental resilience, critical thinking and problem solving, communication and collaboration.

America’s poor showing against countries like Finland, Singapore, and South Korea produced STEM hysteria. Arts advocates worked with marginal success to squeeze art into Common Core and nudge STEM toward STEAM. Forget about humanities. We might be technological savages but nothing mattered except that we test well on science, technology, engineering, and math.

In those days, education reform attempted to address all the factors that determine educational achievement—not just standardized test scores, but high-school continuation versus dropout rates, college entrance and dropout rates and job attainment, and in particular, extreme racial and ethnic inequality in all these measures. This disparity was becoming not less but more pronounced, as evidenced by the 2013

announcement by the College Board that *average* SAT scores across the country had dropped in 2011 and 2012 and were flat in 2013, while the number of *high* scores had increased more than 20 percent since 2007.¹² This meant that more kids were doing worse, while a small top tier was doing much, much better. Unsurprisingly, this mirrored the increasing inequality of America’s wealth structure at large. There were cries on the right against “class warfare,” and on the left in favor of it.

As America’s recovery from the Great Recession of 2008 lagged, revenue-strapped states and school districts radically defunded education, closed schools, eliminated courses, fired teachers, and enlarged classes. Out with arts, which we know cultivate mental capacities and improve academic achievement (as if they were not fundamental to human development in their own right). Out with physical education (never mind the obesity epidemic).

Amid all this we continued to lay on schools the responsibility to remediate every social, cultural, and economic problem kids came in with—dysfunctional families, irresponsible parenting, poor health, poor nutrition, psychological disorders, bad neighborhoods, drugs—while presumably shaping them up for successful college and employment. *In loco parentis* became *in toto parentis*.

Finally, some of us in the design community decided that education was a social design problem and that we’d better get on with it. We already knew a lot about *what* needed to be done. And out there in the world were demonstrations of *how to think about* redesigning learning. Here are two instructive cases that I happened to be involved with first-hand. One was an extraordinary high school. The other was a smart nation-state.

NOCCA: New Orleans Center for Creative Arts

The New Orleans Center for Creative Arts (NOCCA), founded in 1973, was one of America’s preeminent high-school arts conservatories, producing musicians like Wynton and Branford

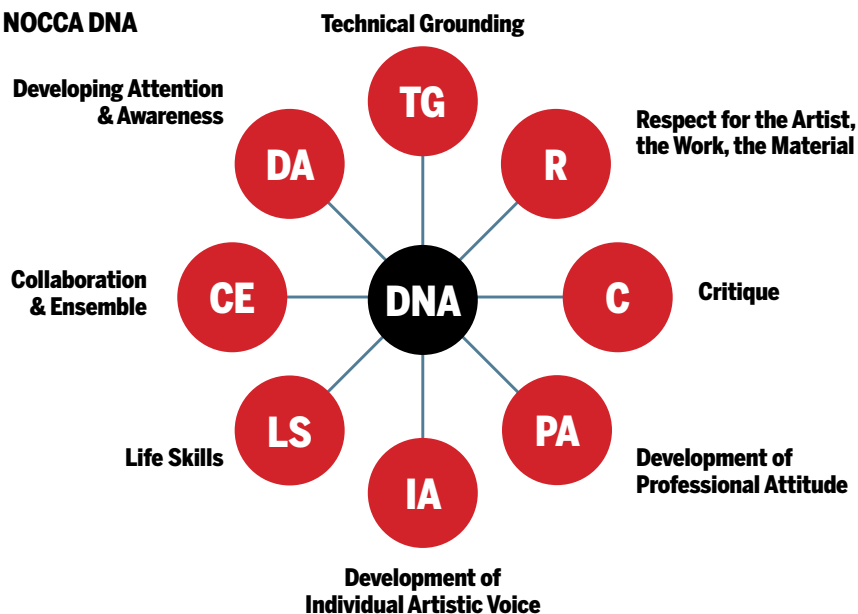
FIGURE 1: THE ACADEMIC STUDIO AT THE NEW ORLEANS CENTER FOR CREATIVE ARTS



FIGURES 1 AND 2.

The New Orleans Center for Creative Arts (NOCCA) is one of America's preeminent high-school arts conservatories. In 2005, our consultancy, Collective Invention, began working on a long-range program to help NOCCA develop a full-day residential academic program. Rather than sticking academics onto the arts program, we worked with faculty, administrators, and outside experts to create an entirely new academic curriculum from scratch. First, we deeply analyzed the DNA of NOCCA's arts pedagogy—learning by doing in a master-apprentice model, purpose-driven creativity and inquiry, student-centered learning—then transplanted it into completely new math, science, and humanities curricula.

FIGURE 2: NOCCA DNA



“It is not our schools that are broken; it is our model of learning that is broken.”

John Seely Brown

Marsalis and Harry Connick, Jr., actors like Wendell Pierce, and many other notables in every field of the arts. It was home to one of the most successful arts learning pedagogies. Students, who were admitted solely by arts audition, attended NOCCA tuition-free from highly diverse socio-economic backgrounds and educational preparation, ranging from fourth- to twelfth-grade readiness.

In 2005, our consultancy, Collective Invention, began working on a long-range program to help NOCCA develop a full-day residential academic program to be called the Academic Studio. Rather than sticking academics onto the arts program, we worked with faculty, administrators, and outside experts to create an entirely new academic curriculum from scratch. First, we deeply analyzed the DNA of NOCCA's arts pedagogy—learning by doing in a master-apprentice model, purpose-driven creativity and inquiry, student-centered learning—then transplanted it into completely new math, science, and humanities curricula. NOCCA's was the first academic education innovation effort led by an arts-training institution.

Academic courses started in 2011. In just two years, all Academic Studio students were averaging double-digit growth in every subject as measured by ACT series tests; 89 percent of students were scoring at the highest levels on End of Course tests; and 83 percent of 10th graders were scoring college-ready. Students developed the same passion for math, science, and humanities as they had for music and dance, becoming producers of knowledge just as they were producers of art.

Remaking Singapore

In 2002, the government of Singapore launched a 10-year plan to transform its widely admired efficiency/productivity economy to a creativity/innovation culture. The program was called Remaking Singapore. The reason was that the nation's economic success had priced it out of the market for contract manufacturing, and other AsiaPac countries were challenging its dominance

as the region's premier transshipping entrepot and finance center. Singapore had to move higher up the added-value chain. All the ministries and agencies of Singapore's government were charged to come up with their plan for embedding a new culture of innovation in their own organizations and, in turn, in their national policies and programs.

To assist in this effort, The Idea Factory and Collective Invention worked with a number of ministries, including the ministries of environment, community development and sports; the Economic Development Board; the Media Development Authority; and the Ministry of Information, Communication and the Arts (MICA), which held primary responsibility for the Creative Industries Development portfolio. I was special advisor to MICA and to Design Singapore, the new agency created to carry out the remit to develop the Creative Industries sector.

We had already begun our work in 2000 with the Ministry of Education (MOE), in anticipation of the forthcoming national program. A disruptive transformation of the scope planned by Remaking Singapore had to begin with education—with how students are taught to think, the tools they are given to do it, and the criteria for assessing educational success. In the 40 years since gaining independence, Singapore's superb education system had produced two generations of citizens highly skilled in mathematical, scientific, analytical, and critical thinking. These skills made Singapore a world leader of efficiency, reliability, and execution. They were also skills ideal for employment in Singapore's main industry, which was government. But although this kind of education made Singapore's students superbly tidy pencil-and-paper-test-takers, it did not encourage the messier habits of imaginative, exploratory, trial-and-error creative discovery. Singapore's students were excellent solvers of well-defined problems, but they were uncomfortable with ill-defined, unstructured challenges—the wicked problems for which there is no single correct answer and that characterize most innovations. Anybody who has been involved in creative

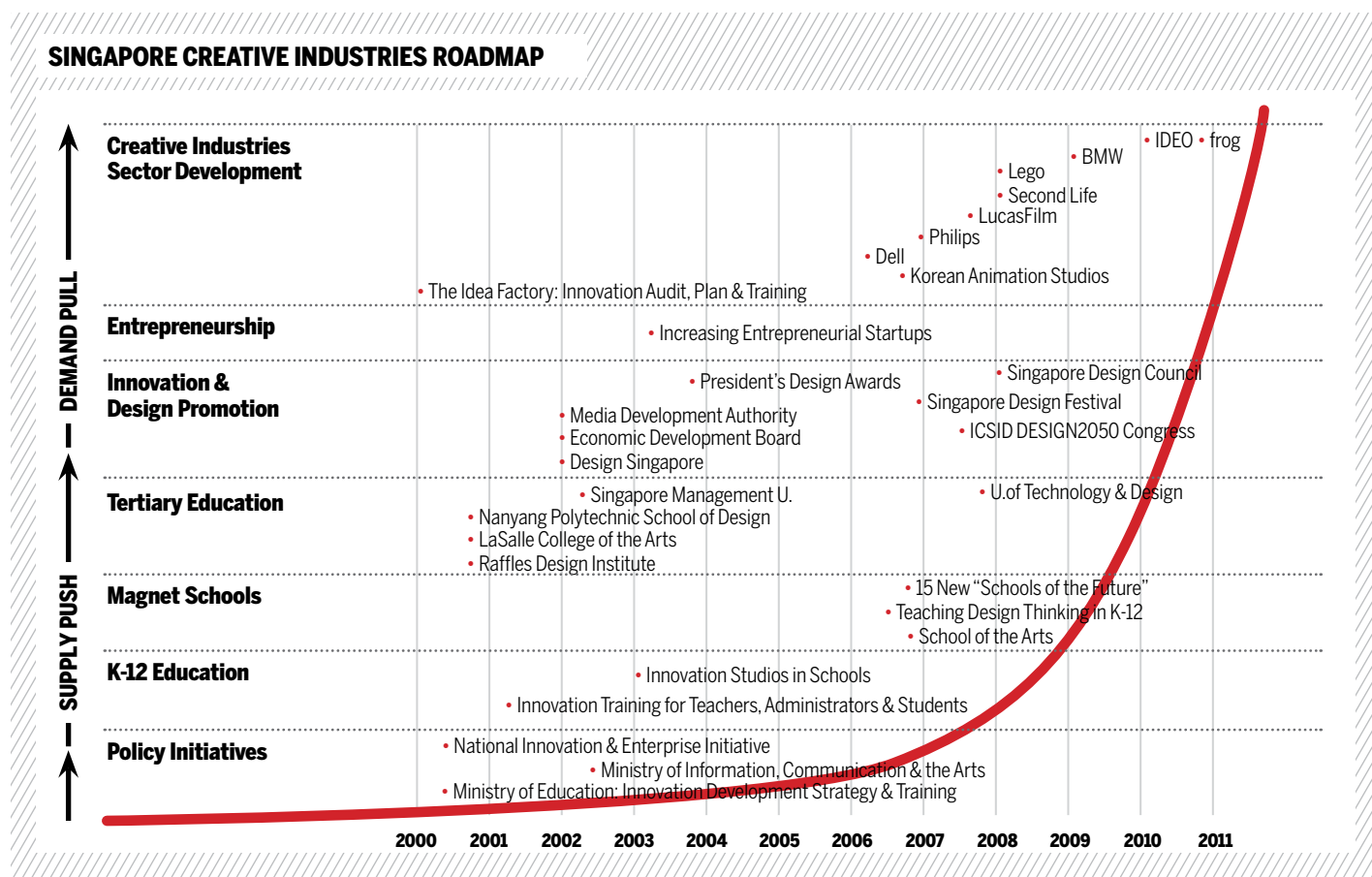
Notes

13. (For a full description of the program, see Creative Industries Development Strategy, 2002: <http://bit.ly/1gAHBCK> .

FIGURE 3 (BELOW).

Evolution of Singapore's innovation and design development from 2000 through 2013. The foundation block established the policy initiatives and assignment of responsibilities. On top of this were built three levels of education. This was the supply push end of the pipeline. The demand

pull end of the pipeline would include awareness and promotion programs by such dedicated agencies as Design Singapore and Singapore Design Council. At the top would be the new entrepreneurial ventures of the creative industries sector providing jobs for the new creative cohorts.



innovation knows that it requires a high tolerance for trial and error, uncertainty, confusion, paradox, and most of all, the willingness to “fail forward” fast and frequently. In order to Remake Singapore, Singaporeans would have to learn new habits of mind, new thinking skills, and new definitions of success. This would have to begin in K-12 schools. And before that could happen, it would have to happen within the MOE organization itself, for that was where all curricula, pedagogy, and assessment methods originated.¹³

A key element of Singapore's plan to become a creativity/innovation powerhouse was the Creative Industries Development Program. Singapore's plan stated that a key contributor to the creative economy would be the Creative

Cluster, which was defined as “those industries which have their origin in individual creativity, skill, and talent and which have a potential for wealth and job creation through the generation and exploitation of intellectual property.”

Singapore categorized the creative industries into three broad groups:

- **Arts and Culture:** Performing arts, visual arts, literary arts, photography, crafts, libraries, museums, galleries, archives, auctions, impresarios, heritage sites, performing arts sites, festivals, and arts supporting enterprises
- **Design:** Advertising, architecture, web and software, graphics, industrial product, fashion, communications, interior and environmental design

“We have to prepare students not for a ‘life of tests’ but for the ‘test of life.’”

“Singapore is a test meritocracy. America is a talent meritocracy. Singapore must become a talent meritocracy.” Lee Kuan Yew, Minister Mentor, Singapore

• *Media:* Broadcast (including radio, television, and cable), digital media (including software and computer services), film and video, recorded music, and publishing

In 2001, our consultancies began training an internal cadre of MOE officers in innovation and design processes. That first group of 20 officers went on to train others, who trained still others, until hundreds of officers were qualified in our Innovation Protocol using our Design Tool Set.

The illustration (Figure 3 on page 69) tracks the evolution of Singapore’s innovation and design development from 2000 through 2013. The entries are representative, but not exhaustive, of the activities in the seven building blocks that comprise the architecture of the program. The foundation block established the policy initiatives and assignment of responsibilities. On top of this were built three levels of education. This was the supply push end of the pipeline, destined to deliver the new gene pool of creative innovators. The demand pull end of the pipeline would include awareness and promotion programs by dedicated agencies like Design Singapore and Singapore Design Council. At the top would be the new entrepreneurial ventures of the creative industries sector, providing jobs for the new creative cohorts.

The curve represents how, after initial ramp-up, initiatives began to accelerate around 2005, creating a positive feedback effect as assessed by internal and external quantitative and qualitative measures.

Not all the pathways performed equally well. Singapore did well at embedding innovation and design at all levels of education and establishing a world design presence starting from zero. It did well at attracting inward investment from established foreign creative industries. Singapore was always strong at scanning the world for the best of the best, enticing it onshore and then “Singapizing” it. The slowest takeoff was new entrepreneurial startups. The Singapore career path always was to work for a large, established organization, especially government. Individual risk venture was slow to take hold.

LESSONS LEARNED

The first thing we learned was that people in the ministries in Singapore couldn’t understand what we were up to in American education. As Minister Mentor Lee Kuan Yew pointed out: “While we Singaporeans are striving to become creative like you, you Americans are instituting the rigid test regime we are working to get away from!”

Obviously, the Singapore experience could not be transferred directly from that small (population 5.5 million), culturally homogeneous, centrist nation-state to the federal US—so diverse socially, culturally, politically, and geographically. Nevertheless, there were principles one could draw from Singapore about how to approach redesigning learning.

- Build a clear, long-horizon national vision goal: *Where do we want to be, and by when?*
- Define an architecture and pathways toward that goal—with interim milestone objectives.
- Align the redesign of learning and the organization of education with those vision goals and objectives—with progress assessment criteria.
- Apply processes, methods, and tools of innovation and design.
- Scan the world for best practices but stress the invention of local *next* practices.
- Accept that you can’t change what an institution does or how it does it without fundamentally changing the institution.
- Work at a scale where means and ends align and continuous change is effected. In Singapore, that was the scale of the nation-state. In America, that scale would have to be the metropolitan region or the *micropolitan* area—the unit of governance where innovation can actually happen.

LEARN!: The call to action

In 2014, America’s design community decided we had to take action. We—designers, educators, students, scholars, communicators, and patrons of design—took on redesigning learning as our public service mission for this century. This initiative helped kick-start the multi-local national movement that today encompasses



Arnold Wasserman is a consultant for innovation and strategy and a pioneer in the field of human-centered design. He is a principal of Collective Invention in San Francisco and chairman of The Idea Factory, Singapore. He has been head of design for NCR, Xerox, and Unisys Corporations; director of the Raymond Loewy

design office in Paris, and dean of Pratt Institute of Design in New York. Named a Master of Design by Fast Company magazine, he also serves on numerous boards and consults for numerous corporations, governments, NGOs, foundations, international organizations, consortiums, and design councils. Wasserman speaks

and writes frequently at venues around the world. Most recently, he spoke at the Commonwealth Club in San Francisco on Redesigning Learning and as Nierenberg Chair guest professor at Carnegie Mellon University taught a course entitled "Design the Future."

FIGURE 4

The yearly **LEARN!ATHON** is a collection of intensive design labs held in hundreds of metropolitan regions and micropolitan areas, staggered on the calendar so that people from one locality could attend elsewhere, online or in person, and so that there would be at least one hackathon going on somewhere in the US every week. This is an early site mockup from the web forum we created to connect the dots of learning innovation worldwide and build a knowledge community of practice.

LEARNING 3.0 Redesigning K-12 Education for the 21st Century

Learning 3.0 The Context World Metamap Interest Groups My Profile Readings, Reference, Sources, Sites News & Events Directory

Design For Change, India & International

DESIGNER(S): Kiran Bir Sethi & Pranay Desai (India)
ADDITIONAL CREDIT: Jim Ratcliffe (Stanford)
YEAR STARTED: 2010
COUNTRY: India
PRODUCTION: Kiran Bir Sethi, Riverside School
NUMBERS: In 2011, Design for Change reached 33 countries and over 300,000 schools - inspiring hundreds of thousands of children and their teachers and parents to celebrate the fact that change is possible and that they can lead that change!
WEBSITE: www.designforchangecontest.com
VIDEOS: <http://dfcworld.com/>

Kiran Bir Sethi says about the beginning of the project: "We designed a simple toolkit and converted it into eight languages. We gave children a very simple challenge: take one idea, anything that bothers you, choose one week, and change a billion lives, and they did. Stories of change poured in from all over India.

DFC students are designing solutions and implementing acts of change for issues across the world ranging from social evils, environment, education, alcohol, child labor, floods, traffic and discrimination. DFC impacts the children, but also the teachers and communities. DFC has created a curriculum for schools, using the stories as inspirational case studies, allowing the children to become role models for other children. MORE ...

Organizations

Charter High School of Architecture & Design (CHAD) Philadelphia, PA, USA
 DaVinci School, Pasadena, CA, USA
 Design & Architecture Senior High School (DASH) Miami, FL, USA
 Design for Change, International
 Henry Ford Academy, School for Creative Studies Detroit MI, USA
 Hi-Tech High, Los Angeles CA, USA
 Learning To Improve Life Denmark & Sweden
 New Orleans Center for Creative Arts New Orleans, LA, U.S.A.
 Studio H, Bertie County, NC, USA
 School of the Arts, Singapore
 MORE...

People

Harris, Jed
 Henderson, Austin
 Stropkay, Scott
 Wells-Papanek, Doris
 MORE...

more than 300 metropolitan regions and 200 micropolitan areas.

We created a design process that became a fixture of civic life, the yearly **LEARN!ATHON**—intensive design labs held in hundreds of metropolitan regions and micropolitan areas, staggered on the calendar so that people from one locality could attend elsewhere, online or in person, and so that there would be at least one **LEARN!ATHON** going on somewhere in the US every week. We made sure to enlist partners from essential adjacent fields, like learning science, neuroscience, sociology, technology, enterprise, and philanthropy, as well as local residents, parents, students, and mayors and their planning and policy administrators. The very first thing we did was create a web forum to connect the dots of learning innovation worldwide and build a knowledge community of practice. Looking

through my archives, I turned up screens from the very first crude site mockups, one of which appears in Figure 4.

Summing up

Writing from the year 2050, I've described the rise of a new model of learning in which students no longer go to school—instead, school goes to students. Learning is continuous, ubiquitous, embedded, and aligned with economic and social goals. We support learning as the crucial foundation of a life of equity, justice, health, creative opportunity, and sustainable prosperity for all. We learn like we give a damn. ■

51.855 & 51.455 Design the future

School of Design
Carnegie Mellon University

Fall 2013
MW 4:30-7:20pm | mm215

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Design the future: human-centered innovation for exponential times

As corporations, governmental organizations, and civil associations face accelerating change in uncertain times, increasingly they are looking to designers for new ways of thinking and acting. Designers today are engaged as thought leaders, strategists, activists, and agents of change in complex socio-technical problems throughout private, public, civil and philanthropic sectors worldwide.

For designers trained to shape futures defined by uncertainty and change, these exponential times represent unprecedented creative opportunities for innovation. In this course, students explore methods and tools for design in exponential times to shape uncertain futures. Students will explore the forces that drive change in the future (i.e., social, economic, political, environmental, technological), and learn to align innovation strategically with the trajectories of those forces.

The design project that drives everything else is the future of mega-metropolitan regions, the hubs of innovation where 70% of people in the world and 75% of Americans will live in 2050. In the semester long project, students create scenarios for Life 2050 in Metro 3.0, using Pittsburgh as a locus and focusing on a project within urban systems such as Sustainable Production & Consumption, Lifelong Learning, Human Development, and Community Resilience.

The goal of this course is to engage you in the integrated reality of the design world through a semester long project situated in Pittsburgh circa year 2050. You will learn to use long-range strategic scenarios to understand the forces that create change that shapes the design of material culture, communication environments, services, lifestyles, social interactions, and community. The focus of the course is to create design scenarios for sustainable lifestyles (e.g., home, work, learning, health, community, mobility, play). It is our core belief that, the slogan “Design the Future” is an open invitation for designers to rise to the challenges that threaten our collective future and seize the opportunities that turbulent change affords.

In this course you will:

- Understand the role of designers in an explosively dynamic field / profession in a radically transforming world. Challenge yourself to push the boundaries of what you think you can do as a designer.
- Learn the tools, skills, resources required to be a proactive agent of positive change in the planet.
- Learn from researchers and professionals across campus and the Pittsburgh region.
- Gain teamwork experience to understand how high performing multi-disciplinary teams operate. Work and learn from and with each other, in small teams, and as an entire class.
- Integrate rigorous design process and design research. Conduct exploratory, generative and evaluative research, throughout the design process. For each step of the design process you will learn to demonstrate mastery of design methods, design research, and presentation.
- Create design artifacts that demonstrate your understanding of a four step design process: (a) definition, (b) discovery, (c) concept, (d) refinement, reflection, and communicating your design.

1. Approach

The forces that are likely to shape possible futures are complex and dynamic. Unfortunately, there is no simple way to articulate such a complex and dynamically changing design space meaningfully. To overcome such limitations in this course, we use an *eclectic* approach that relies on composite representations. The term *eclecticism* refers to an ancient Greek and Roman philosophical tradition based finding the best available paradigm or set of assumptions for each problem rather than seeking a single paradigm to apply to everything. We operate in the tradition of Nobel Laureate Herb Simon, who coined the term to *satisfice* combining the words *satisfy* and *suffice* to describe a decision-making strategy aimed at reaching an acceptability threshold rather than finding the best possible option.

Shaping the future is a wicked problem. *Wicked problems* are often described as difficult problems to solve due to incomplete, contradictory, and changing requirements. *Wicked problems* are contrasted to relatively *tame* problems where the actual problem to solve is easily defined. *Wicked problems* cannot be solved with traditional approaches where the problem is defined, analyzed, and solved in sequential steps because there is not clear problem definition

(Rittel & Webber 1973). Examples of *wicked problems* include economic, environmental, social, and political issues. *Super wicked problems* include issues such as global climate change where time is running out, there is no central authority, those solving the problem caused the problem, and policies discount the future (Levin, Cashore, Bernstein, & Auld 2012).

When working on *super wicked* or *wicked* problems *design agility* is necessary. All design tools, methods, and processes have strengths and limitations. Designers demonstrate *design agility* when they quickly adapt their tools, methods, and processes to different contexts quickly and appropriately. Shaping futures defined by uncertainty and change requires *design agility*.

Design problems require exploration. Heuristics are rules of thumb to help designers explore the design space quickly. Heuristics help designers describe the dimensions of the space (e.g., physical, conceptual, social, cultural). Heuristic design frameworks reduce the cognitive load of decision-making by providing conceptual constructs. A heuristic design framework is not a linear process; it orients in a design space and helps organize thoughts.

Each design space you explore will require particular heuristics. To structure your design process in this course, we propose a heuristic design framework. It has three components: frames, domains, and levels.

Frames describe different ways to observe reality and to be in a reality. Ontology is the study of the nature of being, becoming, existence, reality and so forth. Domain ontology is focused on “what is so” within a domain. We focus on four ontological frames to inform design: *insight*, *farsight*, *foresight*, and *topsight*.

- *Insight* regards the present state in the domain of study. For example, a systems model, conditions, realities, conflicts, conversations, and forces at work in an environment.
- *Farsight* is exploring things laterally. What is going on in adjacent and far domains?
- *Foresight* requires exploring the forces that will create change in the future. Tools include: future world scenarios, and desired normative scenarios.
- *Topsight* entails viewing the big picture as a dynamic and evolving interconnected system through time.

Domains are defined as specified spheres of activity or knowledge. Epistemology is the study of knowledge. What one knows is based on the domain in which one is operating. Typical epistemological domain questions include: How can I know and reason about reality? What can I know for certain? What do I see? We use four domains in this course: *context*, *impact*, *experience*, and *form*.

- *Context* describes the “where” around things. Context is the bounded locus of effect, activity, or “power” as the ability to influence the course of events.
- *Impact* regards the “so what” of something. To articulate impact for design, one must articulate theory of change so that it becomes observable and measurable.
- *Experience* pertains to what something feels like. Experience questions involve: what do I do, say, think, and feel? What motivates and influences practices, behaviors, beliefs, values, attitudes, and state of mind?
- *Form* entails what something is. Form regards what we can know aesthetically, sensorially, analytically or deductively about the materiality and qualities of a phenomenon.

Levels describe a real or imaginary scale of amount, or quantity. Field theory is used in mathematics to describe the relationships between fields and subfields. We use field theory to

describe the nested realities and connections between fields. We use the viewing from the ground level to viewing from 30,000 feet to describe six nested levels (e.g., *ground level*, *5K level*, *10K level*, *15K level*, *20K level*, *30K level*). At each level, different components are salient. At the:

- *Ground level*, one easily observes moment-by-moment experience, local situated behavior, people, cyborgs, and other lifeforms.
- *5K level*, one notices tactical artifacts, interventions, and local “goal-seeking structures.” Salient items include: products, environments, communications, and projects.
- *10K level*, local metro-regions, public and private civil entities emerge. Noticeable items include: plans, programs, policies, cities, and university institutions.
- *15 K level*, multilocal, resource-mobilitating organizations and their strategies emerge (e.g., industrial, state and civil entities) along with national interests.
- *20K level*, complex multi-actor socio-technical systems become visible. The focus is: global social, economic, environmental goals for the planet.
- *30K level*, forces of change, strategic uncertainties, risks, alternative worlds, and the future are visible.

A heuristic design framework allows designers to create an external representation and articulate aspects of the design space they are operating within. Being able to visualize and structure a design space helps designers with insights, connections, and opportunities (Klein 2013).

2. Process, steps, and deliverables

In the first weeks of the semester, we’ll use topsight to get the big picture and begin to analyze the forces that are shaping our design space. Throughout the whole design process you should be asking yourself where does this idea, concept, or thought belong in the heuristic design framework? How does that point in the framework relate to our current task?

You will be placed in interdisciplinary teams to design and perform user research, identify product opportunity areas, generate concepts, rough prototypes and walk through scenarios of use, refine your concepts, prototype and communicate a final solution. The final deliverables will be produced in accordance with the client’s feedback. Each team will be required to produce a short presentation in addition to the artifacts of the process such as research findings and iterative rounds of prototypes. We’ll divide the project | course into four sub-projects or steps, as follows:

September 4 – 23 (14 days)

Step 1: Team pathway presentations

During this initial two-week stage, the class will be assigned to teams and explore ideas about the context, the users and the technologies that might be used to support your user experience. The point is to develop a going-in map of the territory that is shared by your team and to explore what kind of research you’ll need to conduct in the next stage. This is an exercise to help you make explicit what you don’t know—not lock you into a design direction. It is also an exercise in teambuilding—for you to identify team member’s strengths and potential roles going forward.

At the end of this two-week assignment your deliverable will be a presentation that details your plan for your exploratory research (with examples) and a territory map and project definition that illustrates your current understanding of what you are working on.

Be clear and courageous with your ideas. Your goal is to learn as much as possible in critiques. Being vague or timid makes it difficult to provide you with the useful feedback you need to proceed. Your job is to communicate ideas that engage us so that you know what to do next (or conversely what to avoid doing). Your goal from every critique is to know what your next steps are.

September 23 - October 16 (22 days)

Step 2: discovery and exploratory research synthesis

The class will work in teams to conduct their research according to the plan developed in stage 1. Each team will be expected to conduct immersive field research.

- You will explore alternative contexts or situations.
- You will talk to real people in the real world.
- Live in other people's shoes.
- We will discuss a range of possible alternatives in class.
- At the same time, you'll need to imagine the technologies, materials, and solutions that may shape everyday life in Pittsburgh in 2050.
- Talk to researchers and administrators around campus.
- You'll understand peer and competitive systems.
- You will look for lifestyle trends.

Your next step will be to frame the areas of product opportunity from a mapping of your research findings. Then, based on your findings, you will develop a set of design implications or framework that will drive your development going forward. You may use personas, scenarios, and other design methods to synthesize your research.

At the end of stage 2 your deliverable will be a short presentation summarizing your research and highlights of specific important details as well as a set of design implications or framework. In short, you will suggest based on what you learned what you learned and propose how to use such insights to inform your design space. You'll present these findings and your implications in class.

Feb 21-March 20 (27 days)

Step 3: experience concept and generative research

Building on the results of stage 2, teams develop a wide range of concepts that respond to your design implications or framework. Teams will explore a variety of breakout development techniques. Personas, scenarios and sketches will drive your prototyping activity. In addition, you'll be conducting more generative research during this stage where you can engage your audience in collaborative design experiences. Each team will communicate their ideas through prototypes shared through a series of critiques for class discussion and at the end of stage 3, through interaction with the client representative—selecting one direction for further refinement.

At the end of stage 3 your deliverable will be the user-centered concept direction that your team will refine, evaluate, and document through your prototypes and presentation.

March 21- April 15 (34 days)

Step 4: refine, evaluate, and communicate

Building on the concept developed in stage 3, you will revise and improve the first iteration of the final product concept. "Expert" interviews, paper prototypes and other forms of evaluation for a product/service conducted with your concepts and real users.

Your team will summarize the project process, the product vision, and provide an overview of the experience, using models, digital prototypes, and scenarios of use.

The deliverables from stage 4 are the refinements to your design concept and documentation of the evaluative research you conducted, a project brief, an emotional piece that communicates the essence of experience with your product/service and/or demo, and the delivery of your short presentation to faculty, the client and peers.

3. Ongoing documentation on the course wikispace

You are expected to document you own design reflections and team process in this course. Each student is expected to keep a personal wikispace reflection space on the course wikispace. If you prefer to use tumblr or another online platform, please post a link to your reflection space to the course wikispace under your personal page under the people page.

<http://DTF-2013.wikispaces.com/>

Each team will be expected to document their work in progress on a class wikispace website or a team blog week. This site will keep your team up to date, provide our sponsors with a view into your progress, and serve as ongoing fodder for your project documentation. Please post a link to your project blog or wiki here:

<http://DTF-2013.wikispaces.com/>

4. Explaining and discussing work

Communicating and discussing your work is an essential part of the design process. It is an indispensable tool for creating good design solutions. Feedback from your colleagues could expose unforeseen problems with your solution, help you to see a new potential direction when you are stuck, or validate the direction you have chosen. Creating good design solutions requires using imagination, expressing visually and expressing a view of the world. When a solution falls short for any reason, discussions can sometimes be a painful ego-deflating experience for you or your team. The following are the guidelines we will use to insure constructive comments and help you learn to use this tool effectively:

First. Critiques are about your **work** not you or your team. Never take what is said about your work personally! Your work is just your work, the idea you had and presented, not a reflection of you as a whole or your worth as a human being.

Second. Be humble. Make sure you understand the critique being made or the question before responding. Repeat the question back to make sure you understood it correctly. If the question is unclear to you, it is appropriate to say, what do you mean, what compels you to say that? Ask for clarifications, so that you can respond appropriately to the issue raised. If you are unsure how to respond to a comment, it is ok to say "That is a really good question. Let me think about that offline and get back to you."

Third. Filter what you hear. Take notes so you remember what people talked about. Be selective about the comments you accept as valid. Be patient and gracious with those kind enough to comment your work. Sometimes, during critiques people are thinking out loud; they are talking to clarify what they understood. Other times the audience may misunderstand what you presented and be responding to something tangential to your project. Listen carefully and take note of where people are confused by your presentation or project. Even people's misunderstandings are helpful for you to clarify what you are trying to communicate. Do not take everything that is said in a critique as a cardinal rule. Comments occur in context. Listen

carefully to what is being said so that you can interpret it. Remember design is not an exact science. Remember that your colleague's opinion may be an irrelevant perception.

Fourth. It is important to know what others think is "right on" in your project and what they think is "unresolved." Without both perspectives iteration and refinement becomes a random hit or miss exercise. You need feedback from others to see your work from other vantage points.

Fifth. When giving comments, always put a positive spin on the things you say. There are no bad solutions in this class (only more appropriate or less appropriate solutions, more or less successful). Please offer your reasons for your opinion. It is important to develop a vocabulary we can all use and understand when talking about design. Developing an active dialogue is invaluable in learning about design. Try to use words and phrases that refer to the look of the piece you are talking about or the feel of it (how it feels to you). For example: It would be appropriate to point out the angular quality of a typeface, how something looks busy or to describe a spatial relationship between several elements as tense, awkward, comfortable, balanced, or static. Much of the language of design is language we use every day. We use terms that describe relationships to characterize qualities of two and three-dimensional space and their impact in conveying the intended purpose and/or message.

Sixth. Students need to respect the time and efforts of their classmates. When student teams are presenting their work, it is expected that everyone's laptop and tablet will be closed, phone will be off, and that all students will be giving their full attention to their classmates.

In the land of design consultancies, designers never have enough time or resources to do their work. If you feel a bit overwhelmed by the pace of the class and the amount of work assigned, then this is good practice for industry. A big part of this class is to gain a visceral feeling for what designers experience everyday. I want you to work fast and to bring an attitude of play and playfulness to your design actions. The more you make the work fun, the better the design work you will produce.

5. Worksessions and time management

During in class work sessions you are expected to work on your assignment and be engaged with your team members on the assigned task. There is limited time to meet with the instructor and TA during class time. On critique days, it is your responsibility to sign up for a review. Each review session has a start time and end time; the instructor and TA use a timer to stay on schedule. If the meeting before yours runs over, gently remind the instructor to stay on schedule. Prepare an agenda for the meeting. Prioritize your items so we can discuss what is most important to your team first. Questions to prepare for a meeting include:

- What aspect of the project do you need feedback on most?
- Which is the most important issue that you have encountered in your project?
- Do you feel stuck in certain parts of the project? Why do you feel stuck, what are some alternatives you considered?
- What does the team agree on?
- What does the team disagree about?
- How is the team doing?

Teamwork

Teams can be the best and worst way to work. Teams are the best way to work when there are diverse: intelligences, backgrounds, expertise, and people stimulated and energized by such perspectives. Teams are bad when there are complex interpersonal dynamics as the number

increases, lost production due to increased coordination costs, and increased need for communication across disciplinary boundaries. However, complex socio technical systems require teams with multiple expertise and multiple perspectives. Teams work when there is leadership, trust, shared understanding of team dynamics, and the desire to manage the team.

Working productively in a team is a minimum required professional skill for an interaction designer. Well functioning teams produce higher quality work than individuals or merely cooperative groups. In industry, you will likely work with business managers, project managers, software programmers, cognitive scientists, anthropologists, researchers, and all kinds of people with different backgrounds. Being able to collaborate, lead, and be lead on a team is critical to your success as a designer. Furthermore, in industry, you will work with people that are very different from you: from different countries, from different backgrounds, and so forth. At the end of each deliverable, students will be asked to evaluate their own and their teammates performance. These evaluations can influence a grade by up to 10%.

Individual and team skills

Group work can be challenging for many reasons, ranging from the relevant experiences and skills that group members have (or do not have) to the availability of group members outside of class. Answering the questions for this assignment and sharing them with your group members will help the group identify its members' strengths and address possible challenges. You will need to turn in this survey for each group project along with your team contract.

Respond to the questions below:

(a) What strengths do you have relative to this project?

Skills	None	Beginner	Proficient	Expert
Visual design	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Drawing / Sketching	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Design research	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Ethnography / field work	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Prototyping	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Photography	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Video skills	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Programming skills	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Web design	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Teamwork skills	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Group facilitation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Leadership skills	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Presentation skills	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Storytelling	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Written communication	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Future scenarios	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Critical theory	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Other (specify) _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

(b) What would you most like to learn from this project?

Skills	Explain what you want to learn
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Visual design	
---------------	--

Drawing / Sketching	
---------------------	--

Design research	
-----------------	--

Ethnography / field work	
--------------------------	--

Prototyping	
-------------	--

Photography	
-------------	--

Video skills	
--------------	--

Programming skills	
--------------------	--

Web design	
------------	--

Teamwork skills	
-----------------	--

Group facilitation	
--------------------	--

Leadership skills	
-------------------	--

Presentation skills	
---------------------	--

Storytelling	
--------------	--

Written communication	
-----------------------	--

Future scenarios	
------------------	--

Critical theory	
-----------------	--

Other (specify) _____	
-----------------------	--

(c) How are you prioritizing this class? What is your level of commitment to this project?

- ☐ I am going to do stellar work on this project and will make whatever sacrifices are necessary to do so.
- ☐ I want to do great work on this project, but am limited in the time/effort I can dedicate to the project.
- ☐ My goal is simply to get through this project, it is an elective for my major.

Team contract

At the beginning of a team project, teams are expected to discuss and complete a team contract. To prepare for the discussion you will fill out the individual team survey above. In the team contract, you will specify your goals, skills, and expectations of each other as a group.

1. What are your broad team goals?
2. What are the strongest skills that each person can offer?
3. What are the skills that each group member wants to improve most?
4. Who will be the group leader and be responsible for coordinating the group's efforts and sending progress reports to the instructor?
5. What team roles are the other group members filling?
6. How/when will you rotate group roles?
7. How will the group handle a situation in which a group member misses a deadline?
8. How will the group handle a situation in which a group member produces unacceptable work?
9. What procedure will you use to update the team contract when unforeseen circumstances arise?

Sample Team Contract 1

Team Name: _____

Date: _____ Revisions: _____

GOALS: What are our team goals for this project? What do we want to accomplish? What skills do we want to develop or refine?
EXPECTATIONS: What do we expect of one another in regard to attendance at meetings, participation, frequency of communication, the quality of work, etc.?
POLICIES & PROCEDURES: What rules can we agree on to help us meet our goals and expectations?
CONSEQUENCES: How will we address non-performance in regard to these goals, expectations, policies and procedures?

We share these goals and expectations, and agree to these policies, procedures, and consequences.

Team member name

Team member name

Team member name

Team member name

Team Contract Template 2

Team Name:

These are the terms of group conduct and cooperation that we agree on as a team.

Participation: We agree to....

Communication: We agree to...

Meetings: We agree to....

Conduct: We agree to...

Conflict: We agree to...

Deadlines: We agree to...

	Team Member's Name		Team Member's Signature
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6. Readings, videos, websites, and other assignments

Readings, websites, and videos are assigned throughout the semester. Everyone is expected to read, watch, and discuss assigned materials. If it becomes obvious during class discussion that students are unprepared for class discussion and activities, or participating in class discussion, written summaries of each assigned material will be assigned and students will be required to present the readings in class. Readings are posted on <http://ixdcourse.com> and <https://dtf-2013.wikispaces.com/> **Please check both sites for reading materials.**

When reading or watching a video, consider the following questions:

- How does the material relate to the heuristic design framework (e.g., frames, domains, levels)?
- What are the author's three most important points?
- How are these points relevant to you as a designer?
- Was there anything in the assigned reading that confused you? What was it?
- Would you recommend this reading or video to a colleague? Why or why not?
- How does the assigned material relate to your current design projects?
- What are some limitations to the ideas in this paper or video? Does it apply in general cases or in particular ones? What are the exceptions?

7. Overview of Evaluation Criteria

The following criteria will be used to evaluate team and individual performance.

Evaluation Criteria	Description
Leadership and Teamwork	<ul style="list-style-type: none">• Lead by example (Model the way)• Inspire others, develop a shared vision• Constructively challenge one another and take risks• Enable others (the best leaders know when to follow)• Recognize each other's contributions and celebrate victories
Involvement and Growth	<ul style="list-style-type: none">• Regular attendance*• Engagement in the team and class**• Grow personal strengths and engage areas for improvement• Fold new perspectives and disciplines into approach• Strategic thinking: engage "what should we do" not only "how should we do it"
Quality of Ideas	<ul style="list-style-type: none">• Innovative, break new ground• Comprehensive: the ability to look at multiple sides, enlist others as needed, evaluate what it will take to realize the idea within a projected time frame given, technology, market conditions and related factors
Quality of Solution	<ul style="list-style-type: none">• Clear and compelling solution that resonates with target users• Interactive clarity and ingenuity• Visual and physical form resolution• Market viability
Presentation	<ul style="list-style-type: none">• Quality of Materials: Clear, compelling, complete and on time• Delivery that results in engagement and understanding

- Design Process
- Ability to complete stages in an efficient and effective manner
 - Effective use of research and prototype methods
 - Up to date website that captures the team's ongoing engagement

*Regular attendance - You must arrive to class on time and stay until class ends. You may, of course, take reasonable breaks, but class time is expected to be a productive time for all, even when we break into teams and work outside MM215. You are a member of a team; frequent absences and late arrivals are disruptive. If you will not be able to attend class please inform me in advance. After three unexcused absences, your grade may be affected. Three late arrivals, early departures, or sleeping in class incidents will count as one absence. Likewise, three instances of unauthorized computation during class count as an absence (e.g., facebook, linked-in, twittering, texting, email, etc).

**Engagement in the team and class - (Team) you should expect to spend roughly 12 hours per week on the course. We encourage you to carve out regular team meetings and personal work time. As you will see, upfront planning will pay dividends in both quality of the solution AND quality of life. (Class) While not everyone is an extrovert or likes raising their hand, the course thrives on diverse perspectives. You each bring a unique voice to this course. Without everyone's informed view, the class experience is impoverished. Speak Up! If you speak too much, let others speak too. We need to hear from everyone. Naturally, we expect all team and class engagement to be respectful and constructive.

8. Evaluation criteria by deliverable

Criteria	Levels of achievement		
	Sophisticated	Competent	Not yet competent
Stage 1 definition	10		
Team building	Team has energy and enthusiasm, each member has a clear role	Team has energy, but roles are undefined	Team has no cohesion
Clarity of direction	Hypothesis is clear and a draft of a good plan for research is presented	Hypothesis is clear, but research plan is not or vice versa	Hypothesis is confusing and is not tied to research planning
Stage 2 discovery	20		
Quality	Good data collection- the information is accurate; sources are legitimate; appropriate 'reading' of the situations observed or information collected	Information is mostly accurate; 'reading' of one situation may be questionable; sources good but not varied enough	Information is unreliable and/or inaccurate; situations observed don't provide valid data
Broad spectrum of information gathered	Includes dimensions: context, audience, analogous situations, technologies, other systems/competitive landscape	Includes some dimensions	Includes fewer dimensions
Report/presentation of the research	1) Report/presentation of the research process summarizes needs and opportunity areas; 2) highlights key findings; and 3) many insightful implications are drawn from the data	Good report but few insightful implications or vice-versa	Poor report and few implications

Stage 3 concept		20	
Connection to research	Deep and logical connection between research and concept directions developed	Some connections to research conducted, but other important findings are not addressed	Little or no connection to the research conducted
Rigorous design explorations	1) Alternatives explore different facets of use; 2) form evokes appropriate meanings; and 3) scenarios cover several dimensions of use	2 of 3 components are addressed such as: Alternatives explore different facets of use and form evokes appropriate meanings but scenarios are weak	1 of 3 components are addressed such as: Alternatives explore different facets of use but form evokes inappropriate meanings and scenarios don't seem realistic
Effective communication of form and content directions	Sketches and/or prototypes and scenarios of use bring opportunity areas to life.	Uneven sketches or prototypes so it takes lots of explanation and it is difficult to imagine actual use	Sketches and/or prototypes don't get ideas across; difficult to understand how it solution might work.
Stage 4 communication		30	
Product evaluation	Team used systematic testing to validate or drive refinement	Used very informal feedback to drive refinement	No testing or feedback
Quality of craftsmanship and level of completion	1) Final direction works well—the form and the interaction are seamless and 2) it looks great and 3) its complete	Only 2 of the 3 components are addressed such as it works well and looks great, but it's incomplete	Final direction would fail in use and either the interaction or product form are unfinished
Product project brief and quality of the team's reflection on a design solution	Documents process, explains ideas well, clear introduction and conclusion, obvious transitions, doesn't use jargon, demonstrates knowledge of key points	Document is coherent for the most part, but missing 1 or 2 important elements	Document lacks coherence and is missing 3 or more important
Emotional piece	Is an effective summary of the team's efforts and works visually	Is an effective summary of the team's efforts and doesn't work visually or vice versa	Is not an effective summary and does not work visually
Presentation content	Effective slides with coherent and logical progression, covers all key points, slides clearly aid the speaker in telling a coherent story	For the most part slides are helpful in telling the story with only a few glaring problems	Slides interfere with the story
Presentation delivery	Presentation is polished, speakers use sentences, enunciates well, maintains an effective pace and eye contact, doesn't run over allotted time	Presentation is polished, for the most part, but missing 1 or 2 important elements	Presentation is not polished
Connections	Brief, emotional piece and presentation build and enhance one another	Some components relate and others do not	Brief, presentation and poster feel as though different people produced them

Team and self-evaluation		10	
Analysis of group process and individual role within it	Clearly articulates what worked well and why, what did not work well and why, and ways to increase effectiveness and efficiency of group process in the future, considering self as well as others	Discusses only two of the three; discusses group without discussing self; discusses self without discussing group	Does not articulate any of the three – what worked well and why, what didn't work well and why, how to improve
Class Participation		10	
Active participation	Active participation in projects, assignments, attendance/discussions, and critiques	Some participation	Little participation; distracted by computer, phone, and tablet during class time.

9. Recommended Textbooks

- Goodwin, K. (2009). *Designing for the digital age: How to create human-centered products and services*. Indianapolis, IN: Wiley Pub.
- Buxton, W. (2007). *Sketching user experiences: Getting the design right and the right design*. Amsterdam: Elsevier/Morgan Kaufmann.
- Brown, D. M. (2007). *Communicating design: Developing web site documentation for design and planning*. Berkeley, CA: Peachpit Press/New Riders.
- Kolko, J. (2011). *Exposing the magic of design: A practitioner's guide to the methods and theory of synthesis*. New York: Oxford University Press.

Evening reading

- Dorst, K. (2007). *Understanding design: 175 reflections on being a designer*. Corte Madera: Gingko Press.
- Weinschenk, S. (2011). *100 things every designer needs to know about people*. Berkeley, CA: New Riders.
- Weinschenk, S. (2013). *How to get people to do stuff*. Berkeley, CA: New Riders; Pearson Education.

Team work references

- Brown, D.M. (2013) *Designing together: The collaboration and conflict management handbook*. Berkeley, CA: Peachpit Press/New Riders.
- Neill, C. J., Laplante, P. A., & DeFranco, J. F. (2012). *Antipatterns: Managing software organizations and people*. Boca Raton, FL: CRC Press.
- Sutton, R.I. (2010) *The no asshole rule: Building a civilized workplace and surviving one that isn't*. London: Sphere.

Time management references

- Allen, D. (2003). *Getting things done: The art of stress-free productivity*. New York: Penguin.
- Blanchard, K. H., Johnson, S., & Dawson, D. (1983). *The one-minute manager*. Chicago, Ill: Nightingale-Conant Corp.
- Covey, S. R. (1989). *The seven habits of highly effective people: Restoring the character ethic*. New York: Simon and Schuster.

Syllabus References

- Klein, G. A. (2013). *Seeing what others don't: The remarkable ways we gain insights*. PublicAffairs: New York.

Levin, K., Cashore, B., Bernstein, S., & Auld, G. (2012). Overcoming the tragedy of super wicked problems: constraining our future selves to ameliorate global climate change. *Policy Sciences*, 45(2), 123–152. doi:10.1007/s11077-012-9151-0

Rittel, H.W.J. & Webber, M.M. (1973). Dilemmas in a General Theory of Planning. *Policy Sciences* 4: 155–169.

Day		Date	Session description
1	M	26-Aug	Designing design
2	W	28-Aug	Collective Invention
	M	2-Sep	Labor day holiday
3	W	4-Sep	Future scenarios: Vision 2050, Redesigning Singapore, Design 2050
4	M	9-Sep	PlanPGH: the metropolitan revolution
5	W	11-Sep	Doom or boom?
6	M	16-Sep	A PGH learning journey
7	W	18-Sep	Dataviz: from open information to embedded knowledge?
8	M	23-Sep	*Present pathway concept 1.0
9	W	25-Sep	The future now: create lab & HCII
10	M	30-Sep	Integrative experience: ideate network
11	W	2-Oct	Design for impact: virtuous or "pious?"
12	M	7-Oct	Worksession and critiques
13	W	9-Oct	Worksession and critiques
14	M	14-Oct	Dry run presentations
15	W	16-Oct	*Present Discovery and exploratory research synthesis 2.0
	F		Mid-term break
16	M	21-Oct	Presentation debrief updates
17	W	23-Oct	Worksession and critiques
18	M	28-Oct	Worksession and critiques
19	W	30-Oct	Dry run presentations
20	M	4-Nov	*Present experience concept 3.0
21	W	6-Nov	Debrief from experience concept
22	M	11-Nov	Speed researching worksession
23	W	13-Nov	Worksession and critiques
24	M	18-Nov	Results from speed researching
25	W	20-Nov	*Final design sketched out (critique) 4.0
26	M	25-Nov	Movie storyboards, movie script read through, time and presentation outline
	W	27-Nov	Thanksgiving holiday
27	M	2-Dec	Rough cut presentation and rough movie crit
28	W	4-Dec	Dry run presentation
	F	6-Dec	Last day of classes
29?	M	9-Dec	*Final presentation? 5.0?
29?	W	11-Dec	*Final presentation? 5.0?



Nierenberg Chair



We're pleased to announce that Arnold Wasserman has joined the School of Design as the 2013-2014 Nierenberg Chair.

Arnold Wasserman is chairman of the Idea Factory, a consultancy based in Singapore, specializing in innovation, strategy, and design. He is also Founding Partner of Collective Invention, an innovation consultancy based in San Francisco focused on “innovation for the common good” to improve life in

the public domain. He has been named one of “20 Masters of Design” by *Fast Company*. He has held the positions of Vice President of Corporate Industrial Design/Human Factors at NCR, Xerox, and Unisys Corporation. He has also been Dean of Pratt Institute’s School of Design; Senior Fellow for Design Strategy at IDEO, a product development consultancy; and Director of Design for the Raymond Loewy design office in Paris.

Wasserman has been a pioneer in the practice of human-centered, interdisciplinary innovation strategy for the creation of products, services, new ventures, and public policy programs, and for workplace environments that foster organizational creativity and interdisciplinary innovation.

Wasserman writes and lectures frequently on design, strategy, management, and innovation. He has been keynote speaker for The Conference Board in New York City; The National Association of Homebuilders in San Francisco and in Santa Barbara; INDEX: International Design Awards, Copenhagen; The Creative Industry Management Strategy International Forum in Taiwan; the Creative Industries Development Initiative and Design Education Initiative, both in Singapore; Microsoft’s Partners in Learning Conference in Winnipeg, Canada; the Business & Innovation Conference of the Norwegian Design Council, Oslo; the New Enterprise Innovation Conference of the Singapore Design Council; the Global Design Network Congress in Hong Kong; the CLASE Accion Por La Educacion Congress in Mexico City and the National Innovation Strategy Congress in Bogota Colombia. Most recently he was interviewed at the Commonwealth Club of California on the subject of “Redesigning Learning – Hope or Hype?”

He hosted the first forum of the “CMU Inside Stories” speaker series in Silicon Valley.

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UPCOMING

MAY 17 School of Design Diploma Ceremony & Reception

Congratulations to the Class of 2014. Commencement is held today.

MAY 18 Carnegie Mellon University Commencement

College of Fine Arts (CFA) Robing & Lineup for University Commencement Ceremony

MAY 21 2014 Staff Picnic

Staff are invited to celebrate the end of another successful year with President Suresh and EVP Mark Kamlet.

Design is the intermediary between information and understanding.

— Richard Grefé



Peter Scupelli

Assistant Professor

pgs@andrew.cmu.edu

Peter Scupelli is an Assistant Professor in the School of Design. He teaches both undergraduate and graduate level courses (e.g., Senior Studio, Basic Interaction, Interaction Design Seminar II, Graduate Design Studio II, Design Ethos and Action).

Peter's design research centers on interaction design for artifacts, environments, and services. Current topics of interest include: behavior change linked to sustainable, healthy lifestyles, and design evaluation.

Peter's training and career path link architecture, interaction design, and human-computer interaction research. He completed his Ph.D. at the Human-Computer Interaction Institute in the School of Computer Science at Carnegie Mellon University. His dissertation focused on how the architecture of the built environment around large schedule displays and nursing control desks support coordination services in surgical suites.

Peter has a master's degree in interaction design from the School of Design at Carnegie Mellon University. His thesis essay explored the effect of affordances in communities of practice. His thesis project entailed making process work visible to design teams throughout a project in time-shared project rooms.

His architecture degree is from the Università di Genova in Italy. His thesis "Strangers in the residual spaces of the contemporary city" focused on the role of obsolete parts of the city as community resources.

While in Italy, he worked in architecture studios in Milan and was part of the A12 architecture collective. His interest in physical environments and information technology emerged while collaborating with new media artists on installations in museums and art galleries.

He collaborated with A12 and Udo Noll on Parole, an online architecture glossary. Parole was in the VII Architecture Biennial of Venice, PS1 MOMA, New York, the São Paulo Contemporary Art Biennial, and other places. Other collaborations include: Urban Epidemics a city wide installation deployed in Turin, Italy for the Biennial of Young Artists from the Mediterranean; Mirrors, a few reflections on identity, an urban installation in Reggio Emilia, Italy; HUMBOT, at the ZKM museum of Karlsruhe, Germany; A description of the Equator and Øtherlands, at Galerie Schenk in Cologne, Germany, etc.

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