Design Challenge Based Learning (DCBL) and Sustainable Pedagogical Practice

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Design studio-style learning common in schools of design has much to recommend it. If you have ever worked at or attended a design school, you can imagine my shock when I started working at a traditional university and began to recall what it was like to teach and learn in a traditional lecture-style environment more in line with a mainstream mode of teaching and learning. Design studio–style learning fosters a number of very desirable qualities, but it also suffers from some perceived limitations: lack of scalability, possible lack of rigor (primarily in the failure to include core concepts and methods of HCI as curricular material), and a perceived lack of structure and specificity for assignments that is outside of the comfort zone of many students (and professors) who are used to the lecture style of teaching.

Over the past several years, I have worried about these issues—about the balance between my love and experience of studio-based learning and my need to work within a traditional university environment at scale, with structure, and with rigor. The notion of studio culture and learning in interaction design has been a matter of interest in HCI [1]. After much experimentation, beginning last fall I was finally able to translate my concerns into a pedagogical paradigm that appears to work well and has evolved from my practice and thinking as much or more than it has evolved from specific scholarship about teaching and learning. To be complete, I would call this paradigm collaborative competitive challenge based studio learning (C3SL). The term "design challenge based learning" (DCBL), however, is shorter and—though perhaps less precise—may serve better. Plus, DCBL calls to mind "decibel." Let's regard C3SL and DCBL as synonyms. There are many other "X"-based learning paradigms, primarily in the K-12 constructivist education literature, including problem-based learning, project-based learning, inquiry-based learning, and even challenge-based learning, and other closely related paradigms under the gen-

[1] Blevis, E., Lim, Y., Stolterman, E., Wolf, T. V., and Sato, K. (2007). "Supporting Design Studio Culture in HCI." In CHI '07 *Extended Abstracts on Human Factors in Computing Systems.* CHI '07. New York: ACM, 2007.

TWO WEEK PERIOD	SESSION ONE (ALL)	SESSION TWO (SUBGROUPS)
Week A: design research challenge competition	As an entire class assembly, (i) finalists participate in the final competition and critique of the preceding week's design research projects. (ii) A corresponding design concept project is explained and assigned.	In their respective subgroups, (i) students present their individual initial sketches for the design concept project assigned in session one. (ii) Students elect finalists to represent their subgroup. (iii) Students engage in collaborative work on the elected projects.
Week B: design concept challenge competition	As an entire class assembly, (i) finalists participate in the final competition and critique of the preceding week's design concept projects. (ii) A new design research project is explained and assigned.	In their respective subgroups, (i) students present their individual initial sketches for the design research project assigned in session one. (ii) Students elect finalists to represent their subgroup. (iii) Students engage in collaborative work on the elected projects.

▸ Figure 1(a). Design Challenge Based Learning (DCBL) Archetypical Structure

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eral form of learning by "X"—especially, learning by design [2].

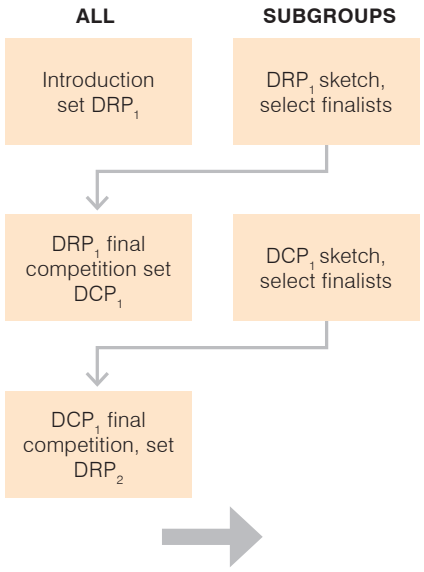
The core idea of DCBL is to present designers with humanity- and life-centered issues-based design research and design-concept challenges in the arena of HCI and design that are manifest as (i) individual, collaborative, and competitive activities involving public presentation and critique; (ii) implicit rather than explicit inclusion of rigorous concepts in the service of motivated design-challenge goals; and (iii) linked pairs of research and concept projects that prompt students to practice ensuring that their concepts follow from research insights and that their research insights lead to concepts.

DCBL is appropriately described in this Sustainably Ours forum, because it is an issues- and values-first pedagogical paradigm. DCBL relates to sustainability in two senses. First, issues of sustainability are potential and frequent challenge topics for the challenge part of DCBL. Second, DCBL is intended as a sustainable pedagogical practice in the sense that it fosters a notion of content that depends on maintaining a current view of vital issues, values, and technologies. DCBL is highly related to transdisciplinary design, which focuses on broader goals such as sustainability, with the intention of "transcending disciplinarity," using disciplinary notions of methods and expertise as needed in the pursuit of these target broader goals [3].

I have taught a sophomore/junior level undergraduate class of 92 students on the topic of HCI and design using the DCBL paradigm. I am in the process of teaching two graduate classes using the paradigm—one on HCI and design with 39 students, and the other on digital imagery in the context of HCI and design with 19 students. The method appears to be working well regardless of class size and is very similar in structure and practice between the three classes.

Figure 1(a) shows the structure of classes according to the DCBL paradigm; Figure 1(b) is an alternative view. Ever week I assign broadly construed issues-based design challenges. The design challenges are of two sorts, namely (i) design research projects, which require students to find and critique existing designs or otherwise understand the motivations and behaviors of people with respect to things designed with the materials of information technologies, and (ii) design concept projects, which require students to use the design research they have undertaken to create conceptual designs that elevate people and life using (or discarding) the materials of information technologies. Figure 2 shows a model design concept project on the theme of sustainability and futuring [4].

Students work individually on the projects at first to create a sketch. Figure 3 shows the model sketch used to inspire the model concept project. The form of this particular example sketch is a semantic differential. This model sketch introduces the semantic differential in a motivated context without abstract instruction about the notion of semantic differentials, and as such, it constitutes an implicit rather than explicit use of the somewhat rigorous notion of semantic differentials as a tool rather than a learning goal in and of itself. Some part of the project assignment instructions is devoted to listing concepts and terms of art in HCI that potentially relate to the project and that the students may want to learn about on their own—such as using a textbook or Google. These concepts are never described explicitly in class in lecture—there are no lec-



▸ Figure 1(b). Design Challenge Based Learning (DCBL) Archetypical Structure: "DRP" denotes "Design Research Project." "DCP" denotes "Design Concept Project." The directed arcs denote individual work, the left-column boxes denote events that occur with the entire assembly, and the right column boxes denote e.vents that occur with subgroups of up to 30.

[2] The constructivist education literature is primarily targeted at K-12 education and is very broad. For an overview of constructivist views of learning and inquiry based learning approaches, see Duffy, T. and Raymer, P. "A Practical Guide and a Constructivist Rationale for Inquiry Based Learning." *Education Technology.* (To Appear). See also: Johnson, L. F., Smith, R.S., Smythe, J. T., and Varon, R. K. "Challenge-Based Learning: An Approach for Our Time." Austin, Texas: The New Media Consortium, 2009. http://www.nmc.org/pdf/Challenge-Based-Learning.pdf/; Savery, J. and Duffy, T. "Problem Based Learning: An Instructional Model and its Constructivist Framework." *Educational Technology,* 35 (1995); Blumenfeld, P., Soloway, E., Marx, R., Krajcik, J., Guzdial, M., and Palincsar, A. "Motivating Project-Based Learning: Sustaining the Doing, Supporting the Learning." *Educational Psychologist*, 26 (June 1991); Kolodner, J., Camp, P., Crismond, D., Fasse, B., Gray, J., Holbrook, J., Puntambekar, S., and Ryan, M. "Problem-based learning meets case-based reasoning in the middle-school science classroom: Putting learning by design(tm) into practice." *The Journal of the Learning Sciences*, 12 (2003).

[3] See especially: Max-Neef, M.A. "Foundations of Transdisciplinarity." *Ecological Economics,* 53, 1 (2005); Nicolescu, B. *Manifesto of Transdisciplinarity.* Translation: Karen-Claire Voss. Albany, NY: SUNY Press, 2002; and, Blevis, E. and Stolterman, E. "Transcending Disciplinary Boundaries in Interaction Design." *interactions* 16, 5 (2009).

BIGGER LABELS = BETTER CHOICES

GOVERNMENT REQUIRED WARNINGS
Use of this product is harmful to the environment. Consider alternatives.

ALTERNATIVES
Consider using refillable more durable containers using local water sources. Consider reusing and refilling this container using local water sources.

✈ ✈ ✈	DISTANCE TO THIS MARKET	300 Miles
☹ ☹	DISPOSAL	6 KG CO2 PER KG
😐	RECYCLE	3.5 KG CO2 PER KG
	ALTERNATIVES	
☺	REUSE AND REFILL	
☺ ☺	CONSIDER MORE DURABLE CONTAINERS	
☺ ☺	USE LOCAL WATER SOURCES	

▸ Figure 2. A model design concept project on the theme of sustainability and futuring inspired by an existent "Smaller Labels = More Trees" promotion.

tures. Nonetheless, many of the students soon learn that doing a little bit of independent study pays off in terms of the success of their projects. In my experience, more than a few even engage in primary observation and other forms of empirical study without ever being explicitly asked to do so, in order to make their projects more competitive.

The students meet in subgroups (of up to 30 or so—a size that will seem too large to K-12 educators but is a logistical reality for the university setting) to discuss their sketches and vote for several of the most compelling ones. The students in the subgroup then work collaboratively with the students for whom they voted to create final projects for an aggregated, competitive critique that is judged in an assembly of the entire class. Points are awarded not only for having a winning project, but also for collaborating, attributing others, and being attributed according to a fairly complex formula. The process is very much in the spirit of several popular reality-based competitive design television shows, especially "Project Runway" and its imitators. Unlike the popular television shows, the design projects pose important fundamental design problems for socially and environmentally conscious designers who work with the materials of information technologies. Also, the grading structure is designed to reward and foster participation and collaboration as well as promote the fun of competition. Finally, the structure provides the sense and feeling of studio-based learning, certainly when the subgroups are small and even when they are quite large.

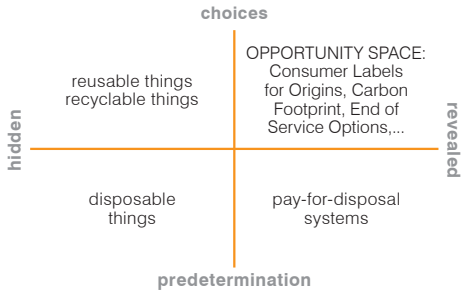
It is easier to fully understand the DCBL approach by looking at more examples of design research challenge projects and design concept challenge projects. Some of the themes I have used and continue to use are time-keeping and time-telling systems, comfort and climate-control systems, music-enjoyment and music-discovery systems, sustainability and futuring, travel and travel-memory preservation systems, food and food-advisor systems, imagery and image-sharing systems, diversity and social-inclusion systems, wayshowing and digital signage systems [5], and others. Since these themes are very broad and the technologies they entail are very dynamic, the reuse of these themes from one semester to another does not appear to be a problem.

In addition to the design concept project of Figure 2, another approach is design research and design concept projects, namely comfortable spaces and comfort-control systems. A very common project in introductory HCI classes is to ask students to design a thermostat that illustrates their understanding of the commonly held but incorrect mental model many people have of a thermostat as a continuous control rather than the switch that its operational semantics actually denote [6]. The DCBL approach in my treatment recasts this problem, not as a problem of incor-

[4] The term "futuring" is in reference to T. Fry's *Design Futuring: Sustainability, Ethics, and New Practice* (Oxford, 2009). The idea of clearer labeling is inspired in part by a workshop position paper presented at CHI 2009: Busse, D. and Wang, W. "Visible Sustainability: Carbon Label 2.0"; and see also Huang, E. M., Blevis, E., Mankoff, J., Nathan, L. P., and Tomlinson, B. 2009. "Defining the role of HCI in the challenges of sustainability." In *Proceedings of the 27th international Conference Extended Abstracts on Human Factors in Computing Systems.* New York: ACM, 2009. The figures for CO2 emissions of disposal and recycling of plastics used in the model can be found at: http://timeforchange.org/plastic-bags-and-plastic-bottles-CO2-emissions/

[5] The term "wayshowing" owes to Per Mollerup's *Wayshowing: A Guide to Environmental Signage Principles and Practices* (Lars Müller Publishers, 2005).

[6] Sharp, H., Rogers, Y., and Preece, J. *Interaction Design: Beyond Human-Computer Interaction.* 2nd ed. Hoboken, NJ: John Wiley and Sons, 2007.



► Figure 3. Sketch (semantic differential) for the model design concept project of Figure 2.

rect mental models and thermostat design per se, but rather as a design research project about what makes a space comfortable paired with a design concept project about how to use digital technologies as a material of creating comfortable spaces. My model solution describes a passive climate control green home as an example of comfort achieved with minimal energy, a Pullman-train dining car as an example of old-world notions of opulence and comfort, and thermostatic climate-control devices in a car and a home that are clearly hopelessly complex and unusable (Figure 4). My model solution for the design concept project describes a wearable encoding of temperature preference and ambient room sensors that enable temperature preferences to follow people rather than be assigned to individual locations (Figure 5).

Concept: E-Ink Fabric Wearable Personal Thermostat and Ambient Sensors

The idea of this concept is that a digital thermostat control is woven into the fabric of clothing or worn like a bracelet or as part of a watch. The control travels with the wearer and electronically signals (many tiny transmitter/receiver technologies are available) desired temperature settings to the ambient sensors in whichever environment the wearer occupies at the moment. The environment—home, office, car, train, plane, etc.—adjusts to the needs of its occupants based on reading the desired setting, averaging desired settings when there is more than one person present, or tailoring to specific individual settings where possible, as in—for example—a car equipped with individual climate-control settings capabilities. When no one is present in a particular environment, that environment does not need to use as much energy to maintain a temperature, and its climate-control system can respond accordingly. There are of course details to work out about how fast an environment needs to react to the entrance of a person and to what extent an environment needs to keep a certain temperature when empty in order to respond quickly. These details need to be worked out as a matter of energy use versus convenience and perceived viability of the system.

Goals of DCBL

The goals of DCBL are to transform learning from certain common traditional ideas to certain ideas inspired by the desire to construct a confluence of studio-style learning with rigor and scale. These goals follow from intuitions about how to use the combination of collaboration, competition, challenge, and studio learning to achieve a sustainable pedagogical practice.

Collaboration

- Instead of asking students to do their own work, ask them to work with others.
- Instead of asking students to put things in their own words, ask them to quote and not paraphrase others.
- Instead of telling students that original ideas are good, ask them to attribute others generously.

Competition

- Instead of asking students not to show their work to anyone else, ask them to seek public critique, and to engage in peer learning.
- Instead of placing yourself—as the professor or lecturer—at the front of the class, ask students to "take over," transferring focus from one student to another frequently and methodically.
- Be prepared—as the professor or lecturer—to publicly recognize the successful attributes of one student's work compared to others, as a form of motivation.

Challenge

- Instead of asking students to engage in problem solving, ask them to ensure that thoughtful problem setting precedes problem solving.
- Instead of asking students to find correct solutions, ask them to find better solutions.
- Instead of asking students to think in values-neutral ways, ask them to orient toward values.

Digital controls for helping to make spaces comfortable:

Why do thermostatic controls vary by location? What does this say about mental models of comfort and climate control, if anything? The vehicle control (top) is needlessly decorative, but very "cute." The home control (bottom) is ugly and the need for the detailed instructions indicates less than thoughtful usability design.

► Figure 4. The familiar thermostat problem recast as a (part of a) model solution for a design research challenge more broadly construed as comfortable spaces and comfort-control systems.

► Figure 5. The familiar thermostat problem recast as a model solution for a design concept challenge more broadly construed as comfortable spaces and comfort-control systems.

• Instead of asking students to undertake either analytic or synthesis tasks, ask them to do both, and to ensure that their analysis leads to synthesis and that their synthesis follows from analysis.

Studio Learning

• Instead of asking students to focus solely on discipline-specific knowledge, ask them to focus equally on transdisciplinary, values-centered goals.

• Instead of setting rigor as a goal for some students or yielding to fear of rigor for some others, ask all students to view rigor as a tool in the construction of evidence for their ideas rather than a targeted end in and of itself.

• Instead of asking students to work in teams, ask students to work sometimes individually, sometimes in small groups, and sometimes as an entire assembly.

• Instead of focusing on tailored learning spaces, focus on managing scale with whatever resources are at hand.

• Instead of thinking—as a professor or instructor—of the core pedagogical skills as being solely domain knowledge and methods, think of the core pedagogical skills as being equally critique and transdisciplinary thinking.

A DESIGN FRAMEWORK					
Analysis			Synthesis		
P	R	I	C	P	S
Predispositions	Research: Literature Observations Ethnography	Insights	Concepts Systems	Prototypes Exploration Appearance Usability	Strategies
↓↑	↓↑	↓↑	↓↑	↓↑	↓↑
A SCIENTIFIC FRAMEWORK					
Initial hypotheses	Literature search	Research hypotheses	Experiment design	Experiment	Results

▸ Figure 6. The PRInCiPleS Framework and its analogy to an idealized scientific framework

• Instead of setting assignments—as a professor or instructor—provide model (better) solutions.

• Instead of constraining scope—as a professor or instructor—push limits.

There are a number of research questions that one can ask about DCBL. For example, does the values-centered transdisciplinary approach of DCBL have the potential to broaden diversity of participation in informatics and computing? Will others use DCBL? How specific to design-oriented HCI is it? What tools must be provided to enable others to use the paradigm? Does DCBL foster motivation and preserve rigor? How can such effects be measured? How well does DCBL scale in class sizes, and what are the effects of implementing DCBL at various scales? What are the implications of DCBL for foundational theories of interaction design and transdisciplinary design?

Some disciplines focus on analytic research and some disciplines focus on synthesis. Design disciplines are interesting because designers need to do both analysis and synthesis tasks. Figure 6 shows a framework we use in our HCI program called PRInCiPleS to provide HCI and design students with a tool for organizing their project work [7]. The framework is not a scientific framework, but it does have an analogy to an idealized notion of a scientific framework. One of the biggest issues in pedagogy is how to get students (and designers in the world of practice also) to ensure that analysis leads to synthesis in a sound way and that synthesis follows from analysis in a sound way. The pairing in DCBL of design research projects and design concept projects is targeted at addressing this issue. The degree of success of this paradigm in so doing is also an open research question with implications for the effectiveness of DCBL as design pedagogy and our hypothesis about DCBL as a pedagogical paradigm that is itself sustainable and that promotes sustainable design.

The syllabi, design challenge project descriptions, and model "solutions" are available on my site (http://eli.informatics.indiana.edu/). Feel free to use them and adapt them [8] if they are useful to you in your own classes. I would be delighted to hear about your experiences if you do so.

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ABOUT THE AUTHOR Eli Blevis is an associate professor of informatics in the Human-Computer Interaction Design program of the School of Informatics and Computing at Indiana University, Bloomington. His primary area of research, and the one for which he is best known, is sustainable interaction design. This area of research and his core expertise are situated within the confluence of human computer interaction as it owes to the computing and cognitive sciences, and design as it owes to the reflection of design criticism and the practice of critical design. His research also engages design theory, digital photography, and studio-based learning.

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[7] The PRInCiPleS framework is my renaming of a notion of a framework for strategic design planning I learned from Greg Prygrocki, Dale Fahnstrom, and Patrick Whitney. I have used this diagram elsewhere, particularly in Blevis, E., and Siegel M. (2005). The Explanation for Design Explanations. 11th International Conference on Human-Computer Interaction: Interaction Design Education and Research: Current and Future Trends, Las Vegas, NV. My colleague Martin A. Siegel and I have adapted, refined, and used the framework as a pedagogical tool in our design-oriented HCI program.

[8] Please feel free to use and adapt these project descriptions, but please do let me know if you are doing so and kindly attribute their use.