Peering into the Discourse of Industrial Design Training through a Sustainability Lens

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Abstract: Now well established in HCI, the lens of sustainability may be applied to educational practices in industrial design and interaction design. By sustainability, we mean to include notions of mitigation of the environmental effects of climate change. In this paper, we present an analysis of student projects in a junior and senior industrial design class dataset. Drawing from discourse analysis, we examine how the industrial design classroom serves as a space to socially construct the philosophies and goals inherent in "good" design. We then examine how the lens of sustainability is implicated into the industrial design "way" as espoused by the discipline's pedagogy.

Keywords: Sustainability, industrial design, human-computer interaction, discourse analysis

1. Introduction

For some time, human-computer interaction (HCI) researchers have been concerned with designing for sustainability (Blevis 2007; DiSalvo et al. 2010; Tomlinson et al. 2008). The perspective of Sustainable Interaction Design (Blevis 2007) argues that sustainability is not simply an add-on or feature of interactive artifacts, but a paramount property of everyday objects that must be made integral in the design process. For instance, any design must consider the lifecycle of the product and its place within an ecology of other older/newer designed artifacts. With the proliferation of mobile devices such as smartphones (Huang and Truong 2008), tablets, and—more recently—smart watches that are seemingly rendered obsolete every few years with newly coveted versions, current design practices arguably still do not treat sustainability as a prime concern. As a review by DiSalvo et al. (2010) attests, there is a gap, which we still believe exists, between the concerns of professional fields of industrial design and interaction design research in sustainable HCI.

Certainly, there have been inroads made towards "making" design sustainable. For example, the Industrial Design of America has adopted the Okala guide to highlight sustainability's importance in the industrial design profession (Walker et al. 2013, p. 125-126). Yet studies have highlighted the challenges of integrating sustainability into industrial design pedagogy (Ramirez 2007; Boks and Diehl 2006): industrial design programs have difficulty adding sustainability to an already full curricula and students find sustainability "requirements" in product development tiresome without overtly visible client buy-in.

In this study we take a critical perspective into industrial design pedagogy by situating our analysis of the DTRS dataset in the transdisciplinary design paradigm (Blevis et al. 2013) of HCI research. Here, we insist on "a values-orientation for interactivity design as higher order concern." While scientific research has never been, nor will be, truly neutral, this "fourth wave" of HCI research (Blevis et al. 2013)—following the ethnographic third wave paradigm (Harrison

et al. 2007) of HCI—argues that researchers have a moral prerogative to create artifacts that are environmentally and socially responsible. Our analysis will contend that any course involving fieldwork, ideation, design, and prototypes of new artifacts needs to have sustainability as an iterative, implicit, and explicit influencing factor. Drawing from critical techniques to unpack the discourse (Phillips and Hardy 2002) of texts (Clarke 2005), we interrogate the pedagogy of the DTRS dataset by asking two broad questions: *what is the philosophy of industrial design, and how does this philosophy intersect with sustainable design?*

As non-specialists in industrial design, we first sought to understand, through the Senior and Junior Industrial Design class dataset, what does industrial design *value*? In other words, what does it mean to accomplish *good* design within the constraints and goals of the classroom environment? Answering these sets of questions, we argue, gives us a first step to understanding, as a whole, what is the design *philosophy* or *way* of industrial designers? By understanding the philosophy of industrial design, researchers can glean the *goals* of industrial design. The rhetoric as espoused and reinforced by instructor, peers, and clients may shed light on how academic institutions are a powerful influence on the sort of objects the next generation of professional industrial designers create.

Second, we ask how the tenets of industrial design, as constructed by the classroom environment, *collude* or, conversely, *facilitate* principles of sustainable design. By attempting to weave both industrial design practices with beliefs of sustainable design, we seek to discover the *missed opportunities* for imparting our belief that socially and environmentally responsible design is a first class property of the design process. Further, we hope that an examination of the pivot points, if you will, between sustainability and industrial design, can inform future teachers and researchers of industrial design how they might better integrate a philosophy of sustainable design with a philosophy of industrial design.

We will argue in our analyses that industrial design's goals and philosophies are structured around several key principles:
- *Make innovation not technology*
- *Designs need to be fun and enjoyable*
- *Create objects that create efficient humans*
- *Maximize designs through multifunctionality: objects that adapt to multiple environments and are shared by multiple people*
- *Generate new product ecosystems and accessories*
- *Follow "Aesthetically Motivated Innovation"*

These principles of industrial design are not meant to be comprehensive, nor independent of each other. Certainly, each principle may overlap with others to varying degrees; for example, aesthetic concerns often overlap with other principles such as making designs fun and enjoyable.

2. Limitations

We wish to issue a disclaimer on our analyses. Certainly, we understand that the classroom environment is necessarily handicapped in what it can achieve. It would be "unfair" to accuse the actors of the class as deliberately ignoring their responsibility to embrace sustainable designs. We did not have access to the entire curriculum of industrial design in our dataset, so it may very well be that later classes more explicitly build in sustainability. Also, our intent is not to criticize

or lambast the participants in these industrial design classes. Because our intent is to weave a narrative on the discourse/rhetoric of industrial design, the tone of some of our writing may seem unnecessarily resistant to any other interpretation than our own. We believe a consistent narrative necessitates a strong, clear picture of a rigorously supported argument on how industrial design's goals are constructed in the classroom environment. However, we acknowledge that our own critical analyses should be subject to the very analyses we have done—another analysis may indeed lead to another, perhaps equally valid, interpretation of what is the philosophy and goal of industrial design.

3. Related Work

While a comprehensive review is outside the scope of this paper, we briefly here review research in three fields. First, we examine studies that have examined the feasibility and challenges in integrating sustainability into industrial design education. Second, we look at literature in interaction design that looks at the intersection of human computer interaction and sustainable practice. Finally, we summarize attempts to bridge industrial and interaction design.

3.1 Sustainability in Industrial Design Education

Sustainability has become an important component of the curriculum in industrial design education. Fletcher and Dewberry (2002) conducted a case study to examine how sustainability issues are addressed in the design process and as a design goal. Peet et al. (2004) discussed the integration of sustainability design into engineering education. Friedman (2012) proposed models of design for future design education. Their article argued that current global economic realities have altered our way of designing, and suggests that the skills that need to be developed for future designers includes sustainability.

Pedagogues and researchers in industrial design education have argued for the integration of sustainability issues into design education. Boks and Diehl (2006) present an undergraduate design course at Deft University that explicitly emphasizes sustainability issues in its curriculum. They examine how different elements of the design course—its course format, definitions of sustainability, business case descriptions, client support, support from coaches (someone in contrast with the client who positively "stimulates" the student teams by acting as a sounding board) and sustainability experts—facilitate the integration of sustainability issues into the course's design cases. Boks and Diehl found that, despite such explicit emphasis on sustainability, students found it hard to reflectively integrate sustainability into design: "They did not know how to, but mainly because they felt there was little incentive to do so. In itself, the perception of the latter reason was stimulated by the lack of stress given to sustainability by clients and coaches, but explicitly also by the lack of evidence that in the real world a sustainable innovation would be in demand or could even survive." Their results also demonstrated that the coaches were the main advocates for students to attend towards sustainability.

Ramirez (2007) conducted a survey study to examine how sustainability has been integrated in industrial design (ID) education. Their findings showed that industrial design educators believe it is important to integrate sustainability evaluation into design curriculum and furthermore that "72 percent believe that their ID graduates demonstrate a reasonable understanding of sustainable design issues and strategies." Yet, in reality, sustainability is not a metric by which students are evaluated in industrial design education. Only half of the design programs in

Ramirez's survey applied a sustainability criteria to assess student's design work, and their curriculum included only 17½ percent or less sustainability-related content.

In summary, these studies examined how design education has attempted to make design sustainable. In most of these studies, the authors view sustainability as a dimension of design rather than the converse—that design is a dimension of sustainability. The extant research focus on how normative design goals fit and conflict with sustainability goals.

3.2 Sustainability in Interaction Design Research

The environmental issues of technological artifacts has been an object of concern in HCI research. An early article by Blevis (2007) proposed a set of principles when considering sustainability in interaction design; in particular, he focuses on how HCI might deal with the increasing damage on our planet's ecosystem brought forth by the development and consumption of pervasive technology. A good review of sustainable HCI literature can be found in DiSalvo et al.'s (2010) article which emphasized the redundancy of findings in current research and the gap between practice and research as well as the gap between research fields themselves (e.g., the ACM and IEEE).

While it is impossible to do a comprehensive overview of the different threads of sustainability and HCI research, we briefly summarize some works that have relevance to our analyses. For example, several works have examined the concept of *durability* in relation to digital objects (Odom et al., 2009, 2012; DiSalvo, 2010; Pan et al., 2010; Hanks et al., 2008). Odom et al. (2009) explored what characteristics make digital artifacts more durable as an impetus to promote sustainable interaction design in HCI. They suggested several properties that encourage durable artifice: single-purposed objects, symbolism to kindle attachment to a device, materials like wood that are associated with durability/attachment, a high degree of possible interactivity, artifacts that record their unique and personal histories, products that promote physical augmentation for reuse/renewal, and a design perceived durability. To understand heirloom objects, Odom et al. (2012) employed a participatory design methodology to study what aspects of certain materials make them desirable to inherit. They found that digital materials were ill-suited for facilitating practices associated with traditional heirloom objects. Based on how families live with digital collections, Odom et al. suggest future digital technologies which consider, for example, the multiple roles family members serve in maintaining their family archives.

Some literature has focused on particular populations' perceptions towards sustainability. Hanks et al. (2008) investigated young people's attitudes and behaviors with respect to sustainability and the effects that the materials our interactive artifacts are composed of have on our planet's environment and resources. The authors conducted a survey of 435 undergraduate students and found most of them were unwilling to dispose digital artifacts, like the idea of remanufacturing for reuse, gave artifacts to others to reuse them, shared digital objects, and seemed to want their artifacts to achieve longevity of use or heirloom status. Thus, while manufacturers may fail to address environmental impacts during the design phase, Hanks et al. show that young consumers are environmentally conscious to some degree and are certainly interested in digital artifacts that are sustainable.

Pan et al. (2010) proposed the examination of *fashion* concepts to understand design in a sustainability context. In their interviews with 30 adults, the researchers asked people to define fashion and to reflect on their choice of digital devices as well as their awareness of sustainability issues when purchasing technology. Fashion was shown to be, for example, intertwined with the cyclical nature of an object's relevance or desirability. Thus, design might consider leveraging fashion's power to create artifacts that have enduring value, symbolize personal identity and extend an item's longevity "as a positive social force to change attitudes in the long run." Sustainability might become "fashionable."

3.3 The Intersection of Industrial Design and Interaction Design

Some scholars have noticed the similarity between industrial design and interaction design. As a result, works have attempted to bridge researchers and practitioners across these seemingly disparate disciplines. For example, Akoglu and Valtonen (2014) did a case study exploring the similarities and differences between industrial design and interaction design during their design process phases. The authors interviewed both industrial designers and interaction designers. Their study found differences between industrial designers and interaction designers in the design language they utilized and in their understanding of users and methods. It was also found that when industrial designers and interaction designers collaborate, they typically have their most intense collaborations relegated to early phases like concept generation. The authors argue that since ICT embedded products have developed at a rapid and global pace, it is important to understand the two design disciplines' product development activities in order to properly support collaboration and cooperation between industrial and interaction designers.

As technology is becoming ubiquitous, industrial designers are also using technologies as materials to design products. Some researchers believe in the eventual convergence of industrial design and interaction design in the future (Kolko, 2004; Vertegaal, 2011). In his article, Vertegaal (2011) claim that just as "web" design has slowly been taken over by graphic design, the design of Organic User Interfaces (OUIs)—interfaces not constrained to screen displays but embedded in physical forms—will require the skills of industrial designers. In the design of "Computational Things," technologies themselves can be considered one of the materials that designers use. Designers need to understand that while physical objects can have physical restrictions, at the same time, they also have their own affordances. Industrial designers are trained to design three-dimensional artifacts and to utilize natural (e.g., wood, metal) materials. Incorporating an understanding of the character of physical materials with the design of interactive artifacts is an important environmental issue. For instance, Vertegaal believes that the reusability of materials in computational products is a vital issue. This is precisely where Vertegaal believes interaction design might learn from industrial design.

4. Methods and Theoretical Lens

We will adopt a discourse analysis (Phillips and Hardy 2002) lens into our critical analyses of the DTRS dataset. This theoretical lens (also considered a method) closely examines discourse—that is, not only what texts (e.g., transcripts of interactions and client presentations in the DTRS dataset) say but how the texts say what they say. Such analysis takes a Foucauldian (Foucault et al. 2003) perspective, arguing that discourse is a form of power enscribed in knowledge gleaned from texts and their dissemination. It posits that reality as we know it is socially constructed

through discourse and the institutions that create, change, reinforce, and disseminate such discourse. In this study, our analysis views pedagogy as a powerful form of discourse that shapes what (budding) industrial designers think of as "proper" and "good" ways to design products for clients.

Drawing from the theoretical lenses above, we apply a critical grounded theory method of textual analysis (Clarke 2005). We coded the DTRS documents to develop emergent themes related to our research questions (i.e., industrial design's philosophy and its intersection—or therein lack of—with sustainability).

Our analyses proceeded in two phases. In the first phase, we analyzed the Industrial Design (Senior) data set. The first two authors separately coded roughly half of the documents from the Senior Industrial Design set. The two authors then met together to analyze intersecting and key themes that emerged from their separate codings. This analyses generated a common code book that was used in the second phase to code the rest of the Graduate dataset as well as the entire Industrial Design (Junior) dataset. During the course of the second phase of analyses, we continued to meet regularly to discuss new codes that were generated in addition to the codes found in our original code book. All documents were coded through the use of the Atlas.ti qualitative software.

5. The Industrial Design Way

We now describe the goals and philosophies of Industrial Design as explicated and inferred through the observed pedagogy from our dataset of students, instructors, and clients.
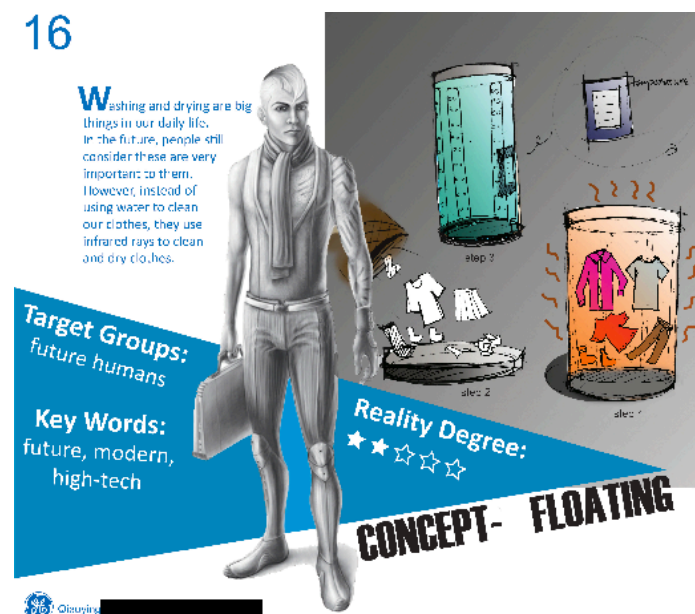
5.1 Make Innovation not Technology

Figure 1. Idea with "Reality Degree" of 2 stars

A key tenet emphasized time and time again in our dataset was that Industrial Design must be *innovative*; it must push boundaries, demonstrate out-of-the-box thinking, and be unique. This philosophy or mindset is instilled in students in the ideation phase. Instructors emphasize that the clients are not looking for something that's already out there. They ask their students to "look at what the [sic] competitors are out there. Do something unique." The artifact that students design must discern itself from other products. Clients "really want us to scare them with crazy, wild ideas, so don't be afraid to let yourself go wild and crazy in your ideations." To inspire students, instructors extol their students to get into their client's minds. Here an instructor tells the students to psychologically prepare themselves for creating ideas:

> Let yourself go and kind of come up with some stuff that's so far out there that they're going to go, "Whoa, these people are on some sort of drug!" (Simon，8:2)

Importantly, this sort of thinking is itself a design process. First, concentrate on creating innovative ideas and worry about the details later. "We really shouldn't worry of the realm of possibility at this point because they [clients] want something…that's impossible. They want something that goes beyond the obvious, so we don't want to discount ideas that might be difficult or problems that are difficult. It's like I don't have a solution for that so I can't write it down. It's fine to write it down without the solution. " (Simon) Thus, *ideation*, the generation of ideas in industrial design is solely focused on ideas that surprise and delight.

Students were consistently told that ideas must push boundaries. Some students took this to heart by making out-of-the-box thinking an explicit, measurable "requirement" of their ideations. One team took it so far as to create a presentation for their client review where each idea had a "reality degree": the degree to which the idea was grounded in reality, or conversely, how wild the idea is (Figure 1).

While in most students' concepts, thinking differently was a mantra emphasized in classrooms, when it came time to choose the "best" idea, instructors were quick to say that "crazy" ideas needed to be grounded in the practical details. Thus students had to accomplish the seemingly difficult task of creating something ground breaking that was nevertheless achievable by the client's company. At times this led to statements from the instructor that may be interpreted as being contradictory. Here, the instructor is examining the students' concepts and is discussing an idea to create a clothes hanger that collapses and folds the clothes for easy storage. The other concepts are described as "a little bit of [pie in the] blue sky," while the folder is extoled as "very pragmatic, [a] real product, [very] producible." Clients like ideas that "we could do…tomorrow and it'd be no problem and it'd be real handy for everybody to have." (Chuck)

Thus, it could be argued that the heart of industrial design's philosophy is innovation tempered by practicality. The capabilities of the client must be considered for any concept to become a "real product" that is producible on a scale. Industrial design pedagogy thus involves discussion of the *underlying technology* that would allow the artifact to become realized. Instructors and clients question how a concept will "actually work" (P22). In the following excerpt, the client (Chuck) queries their students on the physical aspects of two concepts, labeled number 6 and number 8 (Figure 2). For reference, Concept 6 (Figure 2: top) allows people to use a stationary

bicycle to wash their clothes in a compartment in their front wheel, while concept 8 (Figure 2: bottom) is a portable unit that "sucks" stains out of clothes.
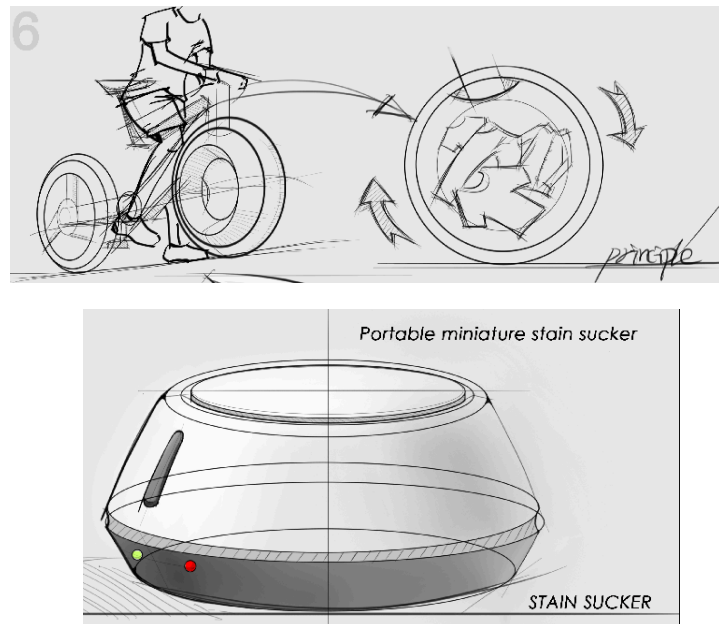

Figure 2. Physical Issues with Concept 6 and 8

Walter: So I mean for the number 6 you would kind of worry about the physical issue and then for number 8 you would worry about the mechanical issue, right…

Chuck: Yeah. So for number 6, like Peter used to work for a bicycle company and he knows a lot about the physics of riding a bike…And the weight involved and the motion of that sloshing water would make it extremely dangerous to ride.

Walter: Uh-huh.

[…]

Chuck: The stain sucker, I think the question is more about just how does it actually work…and what is required to actually remove stains. Okay, that makes sense, okay. So I mean is the technology at a point where it's miniaturized enough for something like this to make sense.

Here the client appreciates that the students have had a range of different concepts: "So I do appreciate the pushing way out and then having some that are…a little bit more…up close…That's a good way to think and a good way to design." (P14) Interestingly the word used in the above excerpt to describe "what must be implemented" is *technology*. More specifically, the students are asked what extant technology can be appropriated to create a novel artifact?

Such a strategy narrowly limits the purview of industrial design. Industrial design is concerned with pushing boundaries in the external form and functionality of artifacts yet within the limits of current technology. It does not seek to simultaneously innovate within the ideation and concept phase *and* the technology the clients may themselves be developing and innovating. For example, manufacturers of laundry machines and chairs may innovate technology but within the confines of the industrial design programme, there is no expectation that industrial design will help with that innovation.

5.2 Designs Need to be Fun and Enjoyable
The discussion and talk about making the user experience to be fun is prevalent in our dataset. Adding fun to the mundane is a crucial criterion for industrial design. In one conversation between the instructor and a student, the instructor claimed that fun and humor are "both are good things. Maybe having a little more humor in laundry is a good idea." (Simon, 36:14) Throughout our data, it is clear that "fun" is promoted in the whole design process.

The design and study of fun is portrayed in a rather intuitive manner. Fun is stated as a research question directly: "How could they [the artifacts] be made fun?" (5:3). With this prerequisite, designers were trying to find out how people add fun to the laundry process during their research phase. Students, instructors, and the client are actively trying to make the mundane—the everyday—fun. For example, much of the research is devoted to discovering the interesting parts of doing laundry, like "finding loose change or Money" (33:38) and "the very reason that she doesn't mind doing laundry is because it makes the flat smell impossibly good in her opinion" (Mylie, 34:10). These are enjoyable side effects that can be capitalized in design. Or the students' research subjects carry out some other activities to distract themselves from the laundry, like "It is not the most enjoyable thing for Lizzy. So to make the process go a little smoother, Lizzy grabs a nice glass of wine and puts on the TV" (5:46) By doing something enjoyable and relaxing, people are relieved from their boring routines.

In the design stage, designers generated concepts making the user experience of their products fun. From our dataset, ideas are about creating fun interaction between family members. This shared interaction allows playful actions and the creation of toy-like features in artifacts. In the design of "sushi roll", "You can do the pattern by yourself and besides, you can do these folding things with your family, with your kids and so the folding is not boring anymore. Use imagination, play with your family" (Eva, 15:4) By having all family members involved in the folding process together, people can enjoy the folding experience and the experience reflects a "happy" or contented family's activity. Another type of concept is designing playful actions, like the concept "Toaster-L". "Cleaned clothes pops out from the machine. User will have more fun using it." (Julian, 27:5) By designing the "pop out" action, it gives fun stimuli to users. Some of the designs made the laundry technology itself a toy. For example, students made the laundry

machine into a rocking horse or "it can look like a dartboard so it actually becomes a kind of a toy that they can… bounce their clothes as balls into it or a basketball kind of…[I]f it's high on the wall it can turn into a basketball kind of idea." (Mylie, 48:8) Figure 3 shows the "Laundry Rocker".
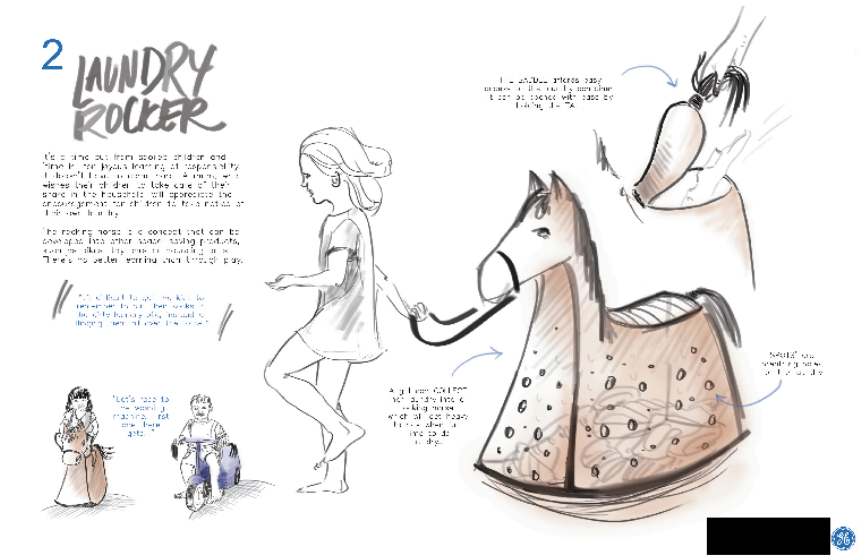

Figure 3. The "Laundry Rocker" Concept

Creating fun is ostensibly a common aim for industrial design. Perhaps a rationale for this design goal is that when people find a product fun, they may prefer it more. After all, industrial designers strive to create objects that encourage their active use: "[I]f it was a toy for them, uh, as well as a laundry basket, they are more likely to actually…take interest and preserve interest as well." (Mylie, 48:4) By making the experience fun, people are more willing to engage with such products.

5.3 Create Objects that Create Efficient Humans

Industrial design values products that are *efficient*. A key philosophy consistently reiterated by industrial design instructors and researchers was to create products that help people multitask and make do with limited resources. Especially in the research stage, students utilizing fieldwork (observations, interviews) and background research found that many of their informants wanted their existing products to allow them to do work more efficiently. Students' research revealed the need to support the modern, busy adult's life. For example, one slide depicting student's research into households of young families without children found a woman complaining about the need to sort clothes and customize temperature settings for different types of clothes, "I'm going to put it on 40 degrees just because I have a cotton sweater. But, if there is any way to do it FASTER, WARMER, and EVERYTHING TOGETHER, that would be nice (05:03)." One couple wants an invisible laundry experience that minimizes any "routine obligatory process".

These statements reflect a need to *reduce steps* in the laundry process. In industrial design, students map out the laundry process, identifying juncture points that could be eliminated or more efficiently sped up through their novel ideations. One student called this the elimination of the "in between steps" that people currently have to make. For example, the artifact in Figure 4 is both a hamper and a container for sorted clothes.
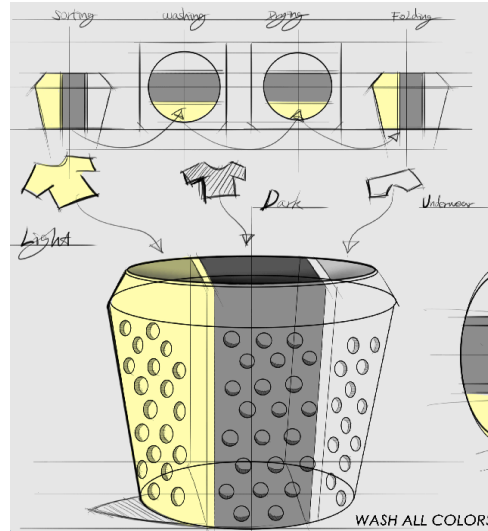

Figure 4. Hamper and Sorted Clothes
Container Combination

The artifact here allows the reuse of the same object to eliminate the step of having to do separate wash cycles for light, dark, and undergarments. Designs allow you to accomplish parallel tasks.

Consumers crave efficiency because time is a valuable resource. As portrayed by the students and instructors, the nominal user is one who is on the move, constantly starved for time. As shown in Figure 5, a team's research has revealed that some users modify their own clothes shopping habits just to save time when doing the laundry.

Figure 5. Saving time and being efficient with laundry is
paramount.

Time is a prevalent thread: informants during the research phase are "rushing straight out, leaving laundry as an evening activity", having "lots of homework to do..no time to do the laundry elaborately", and have "no time during the week to start any laundry" (*05*) as well as "run out of time to fold [clothes]". People forget to put away their clothes because "when it's drying, it will take almost an hour to dry, by that time, I've done so many other things--I [am] distract[ed]."

Particularly revealing are the kinds of people the artifacts are often targeted towards. While research sometimes studies older adults, rural inhabitants or members from less "industrialized" countries, the resultant concepts are invariably targeted towards the modern, busy family archetype. Here an instructor interacts with a student to discuss a suitcase that also irons the clothes inside it:

> Simon: So now I'm getting this concept. I'm liking it more. Alright.
>
> Walter: It's also kind of for your -- It's kind of for the maybe office lady or some business lady that are really busy and maybe right now maybe because really important meeting and they need a really tidy and clean shirt, but they don't have…enough time. So they have just this one. This one -
>
> Simon: The suitcase presses it for you.
>
> Walter: Yeah. And they just put it in your car.
>
> Simon: Alright.
>
> Walter: Actual called ironing suitcase…

Another scenario depicts a busy executive, traveling to hotels. One concept was described as a "tiny washing machine that…can be mounted on the wall. [I]t can be used in some hotels and airports, [if someone wants an] express clean." Industrial design as constructed by our dataset, constructs the user as one always in a rush, trying anything to become more efficient. One student called this "the hectic lifestyle." Industrial design as taught emphasizes that its clients are ones who want concepts that will assist them in their hectic lifestyle.

5.4 Maximize Designs Through Multifunctionality
Maximizing the usage of product is an important criterion for industrial design. From our analysis, one of the common goals of industrial design is to encourage the products to be shared by multiple people. The industrial design students focused on products and activities that could be shared in both the research and conceptual stages. Social actors, activities, products, and motivations are studied in the context of sharing. Then, in the design phrase, various efforts have been put into the design to encourage multiple sharing like making it fun with other people, making it appealing via visualization, allowing multifunctionality, and creating a persuasive design.

Objects that Adapt to Multiple People

In the research dataset, designers are focused on identifying the actors using the artifact involved in the laundry process and the social activities involved in this laundry process. Most of the design research in the graduate course found that parents are trying to have kids involved in doing laundry, while other participants shared laundry facilities with friends. In some interview studies, they found family members who did most laundry work wanted to share laundry duties with their children. For example, in the following family, parents used a clever strategy to get their kids involved in doing laundry - "The kids have a small laundry sack for their clothes in their closet. Which the children have moderate success in getting dirty clothes into it." (Mylie and Dylan, 5:44) Some research noted people also shared laundry facilities with their friends. For instance, the team focusing on culture documented that "When we interviewed her, she said it was expensive to wash clothes in public laundry room, and untidy as well. So she went to her friend's apartment to wash every two weeks." (Sydney and Eva, 7:3) For economic reasons, this student they interviewed shared a laundry machine with her friend.

In their design ideation and concept phase, the students use their design to encourage multiple people to share and involve others in the laundry process. With the consideration of maximal sharing, the students embedded several functions into the laundry machine like making the process *fun, visualized, multifunctional and persuasive*. For example, one team designed a "sushi roll" (Figure 6) folding tool so that "You can do the pattern by yourself and besides, you can do these folding things with your family, with your kids and so the folding is not boring anymore…." (Eva, 15:4)
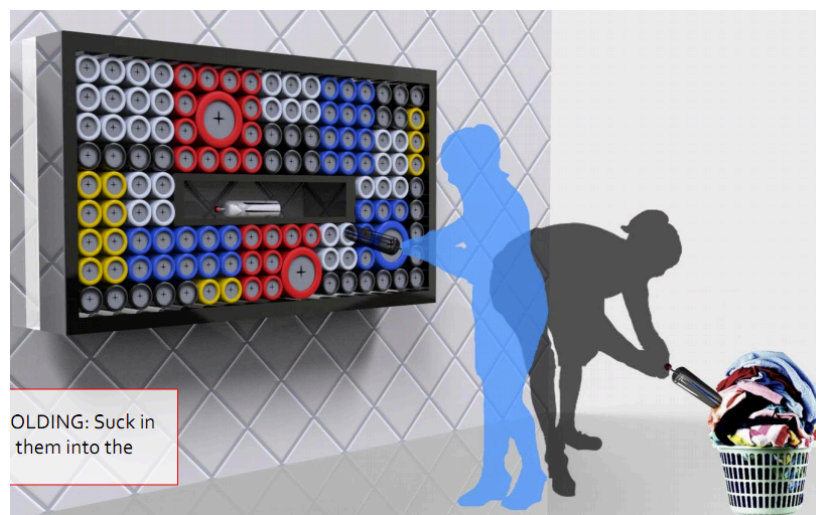

Figure 6. The Sushi Roll Laundry Tool

Another team created an appealing visualization of washing water to entice children into laundry activities. Maximal sharing can also be achieved by designing laundry products to have some additional functionality. "Splash" is a laundry basket designed by one team: "It sits on the wall, rather than collects dust on the floor. It offers an efficient laundry collecting, sorting and washing load management. Its simple idea can be transformed into useful wall sculptures or even children's toys, such darts." (Mylie, 19:6) The laundry facilities here serve not only for washing clothes but as a children's toy; children can play in the laundry process.

Other students designed products in a persuasive manner to convince children to do the laundry. In the aforementioned "Laundry Rocker" concept, the students explain, "so as they [the children], they pile [the clothes], they open the lid, they collect their clothes into it…in time they can rock it, but once it gets full it kind of starts to get really heavy to rock it. So…it kind of reminds them that they…need to do the laundry. So they can take it downstairs to the washing machine and whatever…[S]o it's their responsibility rather than mom's." (Mylie, 48:5) In this design, the weight of the collection of dirty clothes forces the children to do laundry. The weight gives children a sense of responsibility of the laundry activity.

Objects that Adapt to Multiple Environments

One more aim of industrial design is to "create more ways to sit from just one stool". Because industrial designers are limited in how they can *innovate* with technology, much of the pedagogy emphasizes innovating by creating novel and shifting forms of material. These forms emphasize the multifunctionality and adaptability of the designed product. By framing artifacts as being adaptable, designers can "prove" their products as applicable to a wide range of consumers— making the product more easily marketable to clients. Figure 7 illustrates a laundry basket inspired by a "Hammock" and advertised as being able to fit within a wide range of door angles.
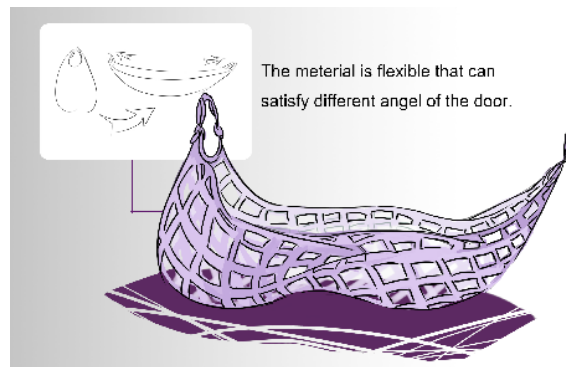

Figure 7. Hammock inspired Laundry

For the laundry case, adaptable forms and multifunctionality help not only with *efficiency* but in utilizing valuable *space*. The research phase constantly revealed that "maximizing space and seamless organization are their main aims." Figure 8 shows a snapshot of research in which the informant complains about the space a hamper takes up:

Figure 8. Problems with having enough space for hampers.

Other informants mention how clothes invariably ends up strewn on the floor, creating a cluttered appearance in their homes, or how laundry machines get in the way of cramped living areas. In the case of chairs (Figure 9), much of the innovation lies in how chairs are stackable and able to transform. Just as time is a valuable resource for these busy customers, space is also scarce.
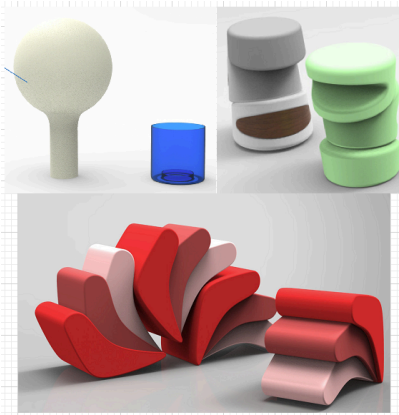

Figure 9. Multifunctional chairs

Designers strive to create additional value for their products. By adding multi-functionality to a product, it can maximize the value of the product. For example, several of the laundry designs combine the concept of exercise and laundry together. Students designed the laundry machine as exercise devices, like bicycles, so that people can exercise while cleaning their clothes. The design in Figure 10 combines a laundry hanger with a hamper/basket.
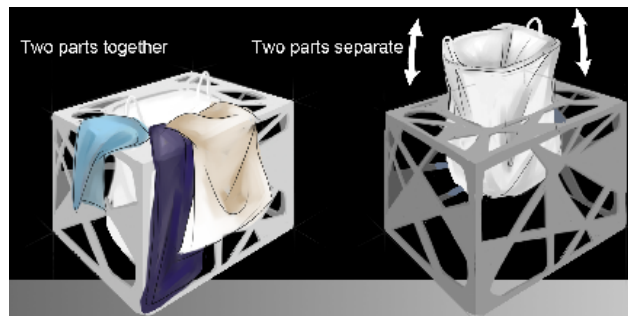

Figure 10. Laundry hanger + Hamper/basket

5.5 Generate New Product Ecosystems and Accessories
On first glance, industrial design may seem limited to the tangible object they are designing: in our case, the chair or the laundry machine. However, the discipline of industrial design is concerned with the product's lifecycle. One way of achieving this is by ensuring that the product is *locked down* with other products that the client will produce. In this discussion, the instructor (Simon) discusses the possibility of pitching "consumables:"

> I know with they're [sic] fridges now they're starting to sell like the filters as a consumable and, um, I just - I'm trying to think when they sell a laundry machine, they

really don't get to sell any consumables with it. And one thing we might look at pitching to them is, you know, GE washer and dryer and GE consumables.

Figure 11. The Breezer

In another example, a student describes a project called "Breezer" (Figure 11) to prolong the clothes's life span for a "sustainable lifestyle". Most significant is the text in the lower right corner: "*AIR is pulled at the bottom and pushed up through the machine. FRESHNER filters could be added.*" Not only is the actual "Freshner" of interest, but the sort of products that could be generated: ensuring continued profitability for the client. Another concept (Figure 12) proposes a tree like structure to hang clothes to support a "sustainable lifestyle".
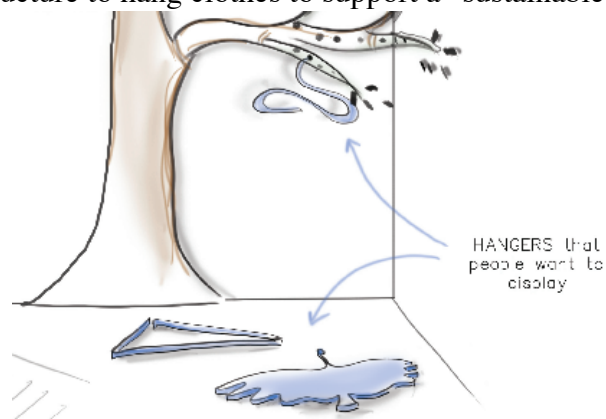

Figure 12. Tree-like Clothes Dryer with Shaped Hanger Accessories

The instructor (Simon) remarks, "Ya' know, I love the idea of having accessories that, that can hang from the branches that allow you to customize it…[I]t supports different functionality…I could even see it being used for things beyond laundry [emphasis added]." Thus industrial design is also concerned with the *accessory* market and the potential for creating such ornaments for their artifacts.

5.6 Follow Aesthetically Motivated Innovation
We noted that students often reflected on how their everyday products could not only be functional objects, but functional objects that deserve to be aesthetically appreciated. The students in our dataset embedded aesthetic values into their designs to add functionality to their products that went beyond the product's core usage (e.g., a chair is for sitting, a laundry machine is for washing clothes).

Why are students adding aesthetic value in their designs? Our dataset shows that the instructor and client encouraged students to embed aesthetic value as if, for industrial design, it is essential for design work. For example, during the first concept review of the junior industrial design studio, the instructor asked a student to reflect on whether his design meets certain requirements. One of the key requirements conveyed is that the product should meet the designer's *own* aesthetic needs. The instructor asked, "Does it still meet my aesthetic needs as a designer?" (P63) He stated that the designer's job "is to bring something exciting into the workplace" though the aesthetic value. This excitement is considered essential to design work. Later, the same instructor repeated: "as designers it [your concept] still meets your aesthetic needs of, of being innovative." The excitement, here, is breaking away from boring ideas and bringing in innovation. Aesthetic value is one of the mediums to *accomplish* the matter of excitement. Because excitement can be brought "in terms of color, like art – functional art you can sit on" [when designing a chair]. Here, the aesthetic value in design work is a reflection of the designer's creativity and ability to be innovative. Thus, industrial design's mission is to create students that have the ability to manipulate visual factors to create aesthetic value, and therefore create products that go beyond their status as an ordinary object. We call this mission's mantra ***aesthetically motivated innovation***.

In our dataset, students adopted different understandings of aesthetically motivated innovation. Students utilized various methods to embed aesthetic value into their design. First, the simplest interpretation of meeting an aesthetic need is to make something beautiful or *visually astonishing*. Industrial designers desire to design something cool. With this aim, some students came out with the idea of adding LED lights to their products. For example, the "sushi roll" design (Figure 6) and "toaster" design (Figure 17) have bright LED fixtures. The LED light is perhaps irrelevant to the function of the particular product. Obviously, LED lights here are a cool visual effect that simply makes the product looks fancy. The aesthetics here is unusual in that it seems to ignores some of industrial design's goals, like efficiency, maximal sharing and multifunctionality.

Related with the goal of creating beautiful designs, materials and shapes are also discussed frequently in our dataset. Again, the choice of materials used in design is motivated by their "coolness" factor; one student explained, "It would be cool to have it [the metal or wood material] in – to be like a, a metal shell and then a wood stool." (P82) Here, the usage of a particular material, like metal or wood, is not for the sake of function or for longevity, but simply

aimed to create a "cool" effect. The design decision about shape has similar motivation. One student explained his design rational: "I think it [the chair] will look nicely when you store it, which I thought will be pretty cool" (P73).

Beyond mere beauty, another goal of aesthetically motivated innovation is to creatively add new *value* to designed artifacts, like turning the object into functional art, a fashion item, or a design that has multiple perspectives. One of the students designed their laundry basket, *Splash*, to be a wall sculpture— "Splash is a laundry basket that aims to look and feel good. It sits on the wall, rather than collects dust on the floor. …Its simple idea can be transformed into useful wall sculptures…"(P19) From the student's point of view, the laundry basket, rather than collecting "dust on the floor," should become useful in the space by having some decorative function. Here, note that the "wall sculpture" is called "useful" because the laundry basket now "aims to look and feel good". In this sense, the embedded aesthetic value is to add value to the product by giving the product a "display" function. Another student's design added aesthetic value by making the product fashionable: "So it is also a sense of fashion that can put in your home, like what they do in shop windows." (P16). In this sense, value is added to the product by making it aesthetically presentable. The product now has *aesthetic value* in addition to its functional value.

In addition, the visual appearance is also used to create novel perspectives of the product. One student designed a stool with a hole at the back of the seat (Figure 13). The reason of the design is, "I wanted something where no matter which way you look at it, it changes a little bit." Therefore, it provides different visual stimuli from different angles. More deeply, the motivation that drove the student to provide different perspectives is that, as she stated at the beginning of final review, "I wanted to create a form that was interesting and different, and that really caught your eye or it was something that you wanted to touch the product and feel the product and use the product." The aim of the visual form here is to, successfully or not, connect people with the product or make the product provocative.

Figure 13. Perspective as an Aesthetically Motivated Innovation

Another question is what is considered aesthetic. For example, one aesthetic value espoused by the instructor is that related to "natural" form. It is interesting to note that having a "natural feeling" is a goal that designers ought to achieve in some designs. In order to achieve this natural

feeling, materials and shape are manipulated. For instance, one product design manipulates shape and material so that you could "stack them [the product] up like fire wood". The instructor also expected students to reflect on the relationship between their materials and nature. He said the student should "look at what you could do with fabrics". The fabrics should be "like something you find in nature."(P62). The reason for creating such a faux natural feeling is perhaps because, visually, (faux) natural material is aesthetically pleasing.

6. Discussion: Sustainability Missed Opportunities

We have discussed the main philosophies and goals of industrial design as taught to students in our dataset. We will now discuss how sustainability itself is sometimes at odds with these principles by first providing two examples. The first example demonstrates an explicit reference to sustainability as conceived by one team: as an "add-on" feature. The second example demonstrates how while the product embodies many of the principles of industrial design as taught by our instructor/clients, in seeking to strive to follow these goals, inadvertently violates or, indeed, supports many of the principles of sustainable design. The last example shows that, even with explicit examples from students regarding current sustainable practices, the goals of industrial design remain domineering and ignore these green practices.
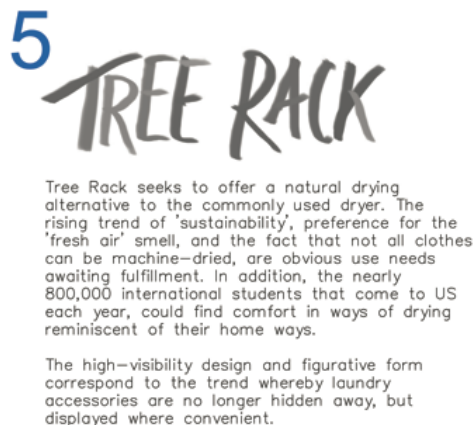
6.1 Explicit Sustainability

Figure 14. Sustainability as Feature in Tree Pack

One team explicitly used sustainability as *feature* of its design. In Figure 14, we see a student's slide explains what is meant by a design that has sustainability: "They note the rising trend of 'sustainability'; this is immediately followed by mentioning the benefits of a fresh air smell and that machine drying is not necessary." Here a client encourages the use of air drying:

Peter: [W]e talk about the dryer…it is very much an energy hog. It uses a lot of energy to move all that moisture out of clothes.

Mylie: Right.

Peter: And anything we can do to promote air drying is, is a definite benefit.

The student also mentions in the research that it is our benefit to support "eco movements or the green movement."

The research phase does reveal that some participants use eco-friendly, organic detergents but again this is framed towards economic viability: "They [consumers] want things easy and of good environmental quality (i.e. organic) and *they are willing to pay for it* [emphasis added]." Despite research showing that people value organic goods, there were no final designs or prototypes that tried to explicitly utilize sustainable products.
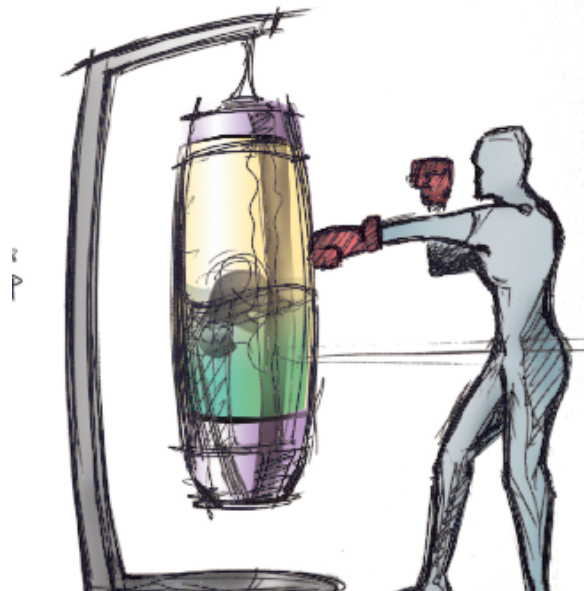

Figure 15. The Punching Bag Laundry

However, in creating products that are efficient, fun, maximize sharing, and multifunctional, many of the resultant designs *did* have sustainable *side effects*. That is, without prodding from the class, designs ended up being sustainable. Not sustainable for sustainability's sake, but sustainable in achieving the principles we have outline for industrial design. For example, the punching bag laundry shown in Figure 15 is meant to create a product that is fun and used by multiple parties. While not meant to be sustainable, the design does embody principles of sustainable design: it promotes sharing amongst multiple parties, it uses a renewal energy source (humans), and allows us to directly be mindful of the resources we are using when doing laundry. Similarly, air drying itself is not really seen as an eco-friendly behavior, rather the designers are seeking to leverage air drying so that it can achieve the effect of providing a pleasant smell (detergent, liner) throughout the home in an visually pleasing way (rather than using dryer racks or clothes lines) in a way that embodies aesthetically motivated innovation.

The correlation between maximal sharing and sustainability is apparent. Indeed, encouraging maximal sharing is a sustainable behavior. However, in our dataset, the focus of maximal sharing is not framed as a sustainable feature in industrial design education. The aims of maximal sharing are more about family interaction or for the consideration of efficiency and profit. In several designs, the concepts that promote sharing of laundry activity with kids, like "sushi roll", are aimed to bring family members together to have fun in mundane activities so to strengthen

family bonds. Some other concepts about maximal sharing are for efficiency; this encourages and persuades children to take responsibility in laundry activities so to reduce the mother's work and to make the whole process more efficient. In some other concepts, it is for economical consideration like the example of using a friend's laundry machine. All these motivations are not for sustainability. However, the side effect of such behaviors can be considered sustainable.
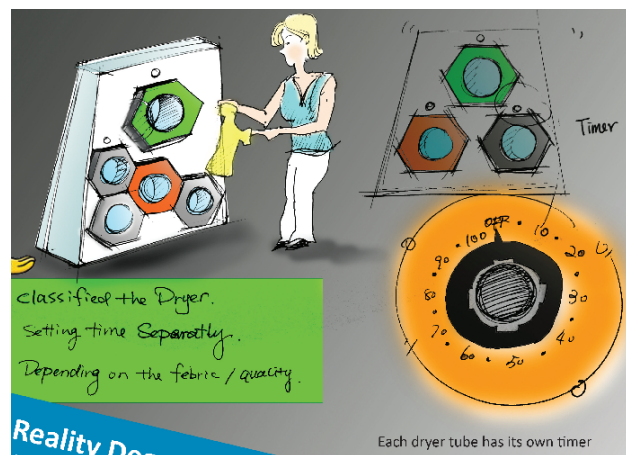
6.2 Implicit Un-sustainability

Figure 16. Implicit Un-sustainability

Conversely, we can consider when such principles directly collide with sustainable practices. The design in Figure 16 supports efficiency and fun. It allows one to quickly sort clothes into separate compartments and wash them all at once.

Yet, if we consider this from a sustainability lens, this product is wasteful. It essentially requires several washing machines to work in parallel. It is not efficient from an energy perspective.

Next, we have a prototype of a design that conceives of a "toaster"-like washing/drying machine (Figure 17). This product perhaps best exemplifies the principles we have discussed. It is efficient, fun (children and adults will enjoy seeing their ready clothes jump out piping hot/dry), space conscious, encourages sharing, integrates accessories, and certainly is innovative, aesthetically.

Figure 12. Toaster Washing/Drying Machine

Yet, this product is conceivably one of the most wasteful products in terms of sustainability. The detergent boxes below take special pellets. In addition, the text reads "the box and detergent in it can be replaced as a whole".
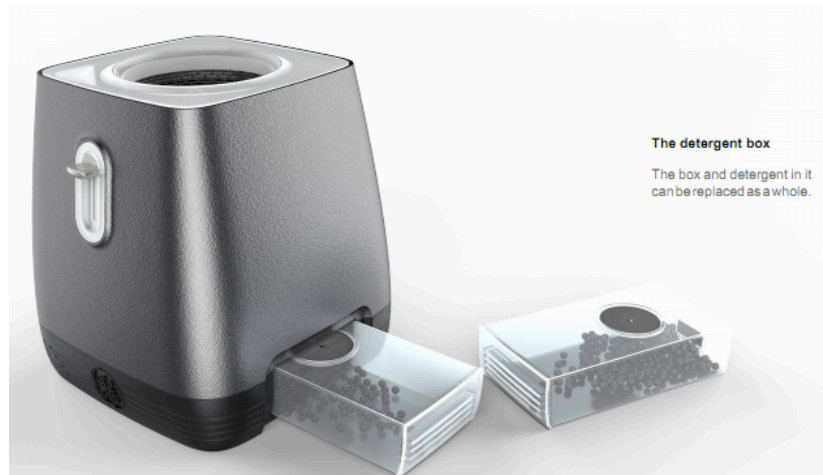

Figure 17. Cartridge system for "Toaster" Washing/Drying Machine

It is unclear and indeed not discussed in class whether these cartridges are reusable or meant to be purchased. If the cartridges cannot be refilled and if the kind of detergent they require is large, this will lead to un-sustainable behavior. Finally, this unit is meant for small loads, to wash t-shirts or underwear. Yet the capacity seems to suggest only one (or a few) clothes at a time can be washed. Thus while the use of accessories, such as customized hangers for drying, may encourage sustainable behavior (air drying clothes, keeping clothes lasting longer), other attempts to accessorize products may have the opposite effect.

6.3 Industrial Design Goals Trumping Sustainable Research
Students in the Senior Industrial Design program did conduct research that revealed what might be considered sustainable practices. For example, the slides presented by Sydney and Eva depict laundry use by different cultures. Laundry use in India, Mexico, and China have sustainable practices: washing clothes by hands, using water from a natural source like a river, line drying and utilizing semiautomatic washing machines (use of feet to rotate the washer) are all examples of laundry practices that consume minimal energy resources.

Eva and Simon talk about the semi-automatic machine. Eva seems to promote the value of such a device.

Eva:	Save the money and also you can exercise.
Simon:	Okay but if you don't put your feet, it doesn't work.
Eva:	Doesn't work at all.
Simon:	Okay. What does it cost?
Eva:	Uh, I don't know but I think everybody can afford it.
Simon:	Okay, was it electric?
Eva:	No, it's um …
Simon:	All manual?

We see here that Simon has mostly flat responses (repeating for clarification, affirming responses like "Okay"). He never speaks to a need to consider the environmental aspects of the design, nor that such green friendly devices might serve as inspiration for the students.

Later, in this dialogue Simon is discussing the fact that only a minority of people who hang dry their clothes in their home country switch to dryers after moving to the USA.

Sydney:	It's means they do hang up the washed clothes in their own country.
[…]	
Eva:	And, uh, most of them said they didn't change their laundry habits.
[0:12:00]	
Simon:	But some do it more frequently, use the dryer 12 percent, okay. Feels dirty.
[Laughter]	
[…]	

Simon:	Okay, all right.
Eva:	Um, you know, I think most of them will depend, you know, because it really depends on how expensive the clothes it is.
Simon:	Okay.
Eva:	If it is just T-shirt, don't care.
Simon:	Okay. This is very nice as far as I can read this quickly and get the results. It's pretty easy to follow even though after a little while I start getting a little tedious because there … but it, it communicates quickly and effectively with your big circle here and I can, I can get the results of it…People hate folding clothes.

As evinced by this passage, Simon is mostly focused on the presentation style of the slides, rather than on the opportunities presented to learn from the sustainable practices of the research subjects. The main take away for Simon is that people hate folding clothes: again, related to the philosophy of creating designs that make people efficient. By the end of the conversation, Simon talks simply trying to make the laundry have humor in it: again, this leads back to creating artifacts that are "fun" and "innovative," rather than sustainable. Thus, despite a myriad of opportunities to comment on overtly sustainable practices (even with prodding from students who seem to have some grasp that these are sustainable practices), Simon continues to focus on the philosophy imbued in Industrial Design pedagogy.

7. Conclusion

As our study revealed, industrial design as framed by the educational program in our dataset is one that seeks to create designs that are *innovative*: designs that push boundaries and create crazy ideas but within the *confines* of what current technologies can achieve. Industrial design views customers as leading hectic lives in which they must prioritize *efficiency* in both *space* and *time*. Designs that are *adaptable and multifunctional* mitigate our struggle with space and time. To reach a broader market, designers must also analyze the processes that people carry out in doing tasks (e.g., laundry, office work) and identify those steps that are cumbersome and mundane/boring. Once identified, industrial designers have a number of ways to cure these problematic steps: making them more *fun* and *inclusive*, creating products that follow aesthetically motivated innovation, and generating new product ecosystems. These industrial design goals that embody its philosophy, we believe, provide a useful *vocabulary* to talk about the education of designers.

Sustainability, as it is now, is merely an "add-on" or "feature" of industrial design that helps *support the industrial design philosophies* we have just outlined. It does not stand on its own. Industrial design students owe its responsibility to clients and the instructor, and not to creating or envisioning or maintaining a future world/environment for future generations. Current industrial design pedagogy practices can implicitly encourage unsustainable practices and do not properly take advantage of opportunities for reflection of the sustainability of certain design

practices. For example, there are many points in the industrial design process where sustainability is only glossed over.

Table 1 presents a first step at examining how industrial design philosophies may facilitate or go against the interaction design principles of sustainability (Blevis, 2007). While not comprehensive, they provide a glimpse at how educators of design may reflect upon how their discipline is taught may implicitly react with sustainability.

Based on Table 1 and our findings, we offer the following suggestions:
1. *Analyzing side effects*: Many of the concepts tried to take advantage of the side effects of processes (natural air freshener = air drying clothes) without consideration of sustainability.
2. *Coupling principles with sustainable practices*: For example, how can we make sustainability fun?
3. *Make sustainability not a feature but its own principle*. Sustainability should not simply be an add-on to industrial design but a principle/mantra on its own. Creating products that are responsible to our planet and lives should be ingrained in students' minds.
4. *Innovate not only within the confines of **technology** but **sustainability**.* We also believe that instructors and clients should work closely with technologists to see if both the physical and the digital can innovate in parallel (rather than confining each other).

Clients and instructors exert a big influence on industrial design students. Clients and instructors are themselves shaped by their own pedagogical background and the programs within which they have been inscribed in. It is understandable that sustainability itself is not discussed at length in these courses. However, it is our contention that sustainability is not simply a feature or a "specialized" course but a key goal/philosophy of industrial design that must be interleaved into its education.

Table 1. Analysis of sustainability principles and material effects in relation to industrial design ethos in an educational context.

Industrial Design Ethos (Purdue Dataset)	Sustainability Principle	Material Hazards	Observed in the Dataset
innovation not technology	invention and disposal	increased disposal	separation of industrial design creative innovation from client technology invention
efficiency	invention and disposal	increased disposal and externalities	saving consumer's time and effort precedes externalized cost considerations
fun	ownership and identity	discarded toys	by making the experience fun, people are more likely to engage in the product use
maximizing sharing with multiple people	quality and equality	-	encourage multiple people to share and involve others
maximizing adaptability to multiple environments	renewal and reuse	the obsolescence of a constituent functional element may cause the obsolescence of the whole	by adding multi-functionality to a product, it can maximize the value of the product
creating product ecosystems and accessories	natural models	increased consumption	continued profitability for the client, industrial design is also concerned with the accessory market
aesthetically motivated innovation	renewal and resuse, decoupling ownership & identity	increased consumption	creating items that are valued for their aesthetical innovation make them more durable and valuable, but may also create superfluous features

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