Learning to Design Backwards: Examining a means to introduce human-centered design processes to teachers and students

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Abstract

'Designing backwards' is presented here as a means to utilize human-centered processes in diverse educational settings to help teachers and students learn to formulate and operate design processes to achieve three sequential and interrelated goals. The first entails teaching them to effectively and empathetically identify, frame and analyze complex social, technological, economic, environmental or public policy problems, or problematic situations. The second involves helping them cultivate understandings from these problem - framing processes to iteratively develop and then assess the relative efficacies of specific prototypes or prototypical ideas that, if implemented, could improve some aspects of these situations on behalf of particular groups of stakeholders. In this context, 'prototyping' is defined as a heuristic process that allows students to test how operating various strategies and procedures, or deploying particular interventions in the forms of communication systems, affordances, and tools and toolkits, can yield insights about how to affect useful, constructive transformations. The third goal challenges students to correlate the knowledge they gleaned from engaging in the first two processes to work with given groups of stakeholders to develop and implement more relevant, effective and appropriate outcomes to the complex challenges that directly or indirectly affect specific aspects of their lives.

Key words

designing backwards, project framing, prototyping, abductive reasoning

An introduction to designing backwards

'Designing backwards' is shorthand slang for engaging in the kinds of thinking processes necessary to design and implement products, services, procedures and experiences that relevantly and effectively meet the needs and desires of particular groups of people. It is a human-centered approach to innovating and inventing that begins by observing and interacting with at least some of the people on whose behalf a given product, service or experience will be created or realized. Designing backwards begins when a situation in a specific setting involving a particular group is identified that, in some way or ways, causes or contributes to their experiencing confusion, frustration, dissatisfaction, discomfort or even harm. Careful observations of multiple incidences of an objectionable situation allows the actions of those involved to be analyzed, along with a variety of factors and conditions that contextualize and affect these actions. The knowledge and understandings these analyses yield can then suggest means of altering the aspects of the situation that make it objectionable or undesirable.

Designing backwards is different from 'designing forwards' in that the decision-making processes that guide its evolution are *not* planned and operated as a means to realize concrete, already well-understood end goals. Empirical measures for success - is it faster or slower? Does it cost less or more? Is it more or less visually compelling? - tend to be trumped by criteria that gauge whether or not a certain population feels more empowered, or safer, or more well-accommodated. It is a process that begins not with a well-specified brief or call-to-action, but with the formation of questions that direct inquiries that lead to insights and new understandings.

The ethnographically rooted activities that fuel designing backwards can help ensure that what a given group actually needs and desires is accounted for as decision-making processes evolve that might eventually yield a new artifact, system, or environment for them to use and experience. Designing backwards can also result in new ways of planning and then doing things, as well as new ways to think about how particular things should or should not be planned or done. The knowledge gleaned from the initial observations and interactions that constitute the basis of these thinking processes can then be used to inform the iterative, cyclic development and testing of *prototypes*.

These processes are endemic to design. Designers working in and across a wide variety of circumstances have utilized them to inform their decision-making for most of the last century. This article will articulate how designing backwards can be used to help meet, or at least address, two primary goals on behalf of pre-collegiate educators and their students. (In the context of this article, pre-collegiate educators are described as teaching students that constitute two, broadly constituted groups: 11-to-14-year olds - in the U.S., often referred to as 'middle-schoolers' - and 15-to-18-year-olds - in the U.S., often referred to as 'high schoolers'.) To meet the first

goal, it can equip pre-collegiate educators and their students with a viable methodology for identifying, framing, and examining complicated issues and questions. To meet the second, it can also, as they deem necessary, provide them with a viable mechanism for developing something that is new and that instigates change and thus "…makes the existing model obsolete" (Fuller, 1981).

In the context of designing backwards, prototypes can and do take many forms. They can manifest themselves as manual sketches, digital renderings or physical models. They can eventually yield a diverse array of outcomes like computing interfaces, systems of cautionary symbols, or promotional posters. Prototypes also emerge as tools or kit of tools, or games, or new ways for a people to engage in the experience of selecting food and then dining in a cafeteria. They can also be realized as a new means for an individual to participate in the act of voting in a political election, or to select the best players for a given year's football, baseball or hockey all-star team, or to sort and then effectively route a diverse array of packages in a mail room.

Designers (and engineers, computer scientists and other practitioners and academics who use them) are taught that a prototype should function as a means to test the ramifications of implementing and then operating something prior to its actual adoption, manufacture, or publication. Prototypes provide designers, their collaborators, and some of those who will eventually view, use or consume what designers create with a process – *prototyping* – for informing and guiding the development of whatever is being designed in an iterative manner. 11-to-18-year-old students who learn to design backwards will be more well-positioned to enter university or the job market as innovative, broad-minded thinkers and planners (Trilling and Fadel, 2009: 8-9). Designing backwards to iteratively develop and test prototypes will also provide them with a viable means to frame, analyze and suggest viable, sustainable ways to ameliorate complex problems (Trilling and Fadel, 2009: 49-54). Additonally, designing backwards immerses students in learning situations that challenge them to construct, rather than merely perform, knowledge, which requires comprehension and critical thinking (Banks, 1993: 5-6). In turn, this helps students become actors in their own learning processes, which helps them learn to reason, create and use new information effectively (Bain, 2004: 58-9).

A brief examination of the historical context for designing backwards

Designing backwards is posited here as a reflective, process-based means to gain and create knowledge, as well as to positively guide transformative actions, on behalf of an affected group. It does not begin by pre-supposing that a particular type of problem, or undesirable situation, can be improved or resolved by engaging in a specific type of thinking. It tends to require lateral ways of thinking that explore and assess multiple possibilities, rather than linear ways of thinking which can yield only one 'right answer'. Its foundation is rooted in discussions that began in earnest during the 1960s during the Design Methods Movement about what should constitute the fundamental activities of design. As the 1960s progressed, the processes used to guide design decision-making began to be touted as a means to effectively engage in scientific research by a group that came to be loosely known as the design methodologists. They included Christopher Alexander, R. Buckminister Fuller, J. Chris Jones and Herbert Simon. By the early 1970s, Alexander and Jones began to suggest that trying to utilize systematic methods rooted in science to understand complex design problems was an inadequate and ineffective way to do this. Unlike scientifically guided processes, the results of design processes are often not replicable, nor should any attempt be made to copy them, and very often they cannot be validated externally (Cross, 2007: 121-122). Design processes, like designing backwards, also tend to begin with some sort of a normative objective - to try and improve something, or a given set of circumstances - and so are structured in ways that they yield results that can be said to be better, or more appropriate, rather than true or false (Rittel and Webber, 1973).

In 1983, Donald Schön published his book *The Reflective Practitioner* (Schön, 1983). It touted the idea that practitioners working in a broad array of disciplines can create more relevant, useful knowledge for themselves by consciously reflecting on what they do as they do it. This constructivist approach argued that practitioners should eschew what he referred to as "technical rationality" (i.e., positivistically informed ways of learning) as a grounding for their professional knowledge. Instead, Schön argued that they should rely on understandings gleaned from "looking to our experiences, connecting with our feelings, and attending to our theories in use" (Smith, 2011). As the 1980s progressed, Schön's ideas about enacting reflective practice resonated positively with practitioners across many disciplines, including designers and educators. He referred to this as "reflecting on action so as to engage in a process of continuous learning" (Schön, 1983: 102-104).

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Enacting and sustaining a reflective practice, and using the knowledge gleaned from this on-going, often cyclic, process is another key tenet of designing backwards. What is being described here is not a systemic, linear, 'plan-and-then-execute' approach: it is antithetical to systematically guided, standardized methods for performing, rather than constructing, knowledge.

Constructivist approaches to planning and operating design processes, like reflective practice and designing backwards, can allow practitioners from a wide variety of disciplines to effectively confront ill-structured, complex problems. The need for practitioners and their collaborators to be able to do this can be traced to Herbert Simon's arguments in *The Sciences of the Artificial* (Simon, 1969), and, more directly, to Rittel and Webber's call to use design thinking to confront these kinds of intricate, convoluted dilemmas that they deemed "wicked problems" (Rittel and Webber, 1973). Additionally, designing backwards calls for modes of inquiry to inform plans for action and, as necessary, the development of whatever tools and methods are needed to realize these plans (Coyne, 2005: 8).

Designing backwards does not require those who engage in it to possess professional design experience or a degree in one of the design disciplines. It is a process, or set of processes, that begins when those involved in or affected by a particular situation identify, or co-identify, at least some aspects of it as somehow being problematic, dissatisfying or annoying to them. In this discourse, these people will be referred to as "the affected group," and their predicament as a "problematic situation." For example, individuals, particularly children living in the U.S., who were infected with measles or mumps in 2014 are an example of an affected group. The fact that they became ill in the first place - as did others who came into contact with them during their infected state - due to their parents not allowing them to be vaccinated against these easily preventable diseases is an example of a problematic situation.

A description of designing backwards as an inclusive, transformative activity

Whoever eventually becomes involved in the efforts to mitigate a distinct undesirable scenario, or problematic situation, the two primary goals of designing backwards are relatively easy to describe, even if the means for achieving them sometimes is not. The first of these linked processes involves engaging in critical and objective examinations of how and why given sets of social, technological, economic, environmental and political factors and conditions influence an affected group living or working within a given situation. The second involves leveraging knowledge gleaned from these examinations to suggest changes to improve the factors and conditions that frame the problematic situation of the affected group.

Designing backwards does not begin by challenging someone, most especially a student, to design a chair, a graphical user interface, a retail space or a garment line. In this context, 'student' refers to two age ranges and maturity levels of individuals: middle-school students aged 11 to 14 years, and high school students aged 15 to 18 years. Working very prescriptively according to a narrowly defined design or problem brief guides decision-making processes in ways that ensure the realization of predictable, often pre-determined outcomes that fit into an (usually) existing, singular-rather-pluralistic, well-defined category. When projects are initiated according to framing statements that specify the 'what' of that which must be designed… 'design a poster that communicates … on behalf of…,' opportunities to think about how to transform the factors and conditions that contextually surround the situation within which the design must function are often lost. In this way, many problem statements and project briefs limit the potential to improve a given state of affairs on behalf of *or with* a particular affected group by categorically constraining the activities of those who could affect change in or around these circumstances.

These types of project briefs also limit designing to an activity that is undertaken *for people* enveloped within a specific set of circumstances, without their involvement and input, rather than an activity that is undertaken *with these people*, where they are allowed to function in at least some ways as co-designers. For example, merely designing *for people* results in the kinds of public relations fueled marketing campaigns that champion a given sponsor's vaguely defined support for American Iraq and Afghanistan war veterans. While these campaigns might help garner some positive publicity for their corporate sponsors, they will likely do little to help these veterans re-adjust to living and working in a society where most jobs do not require the skills necessary to successfully engage in armed combat against cunning adversaries. Similarly, developing and implementing yet another physical fitness mobile app is not likely to effectively address the complex myriad of causal factors that can be linked to why so many people living in G-20 nations are overweight and physically unfit.

Design researchers Liz Sanders and Pieter Stappers have opined that involving end users and intended audiences in design processes supports a mindset "that the end users

are the experts of their future lives," and that "[he/she] is only one person among others whose needs and dreams need to be addressed in product/service development… It is also now acknowledged that all levels of people's needs should be addressed, including ergonomic, cognitive, emotional, social, and cultural needs (Sanders and Stappers, 2014: 25).

Introducing the concept of designing backwards in educational settings

Designing backwards can afford students diverse opportunities to become familiar with a means to envision, and then build and test, that which may not yet exist, at least in its current form. It allows them to:

1. consider real-world problems;
2. engage in research processes;
3. analyze the data they gather;
4. utilize this data to guide the generation of new ideas;
5. engage in experimentation and then;
6. actually construct and test prototypes that can affect the real- world problems they set out to address.

Through prototyping, they can learn to think differently and act in new ways, which can in turn help them to innovate, to challenge and break patterns (Berglund and Grimhelden, 2011). Learning to develop prototypes can also become a means for students to share multiple experiences and viewpoints with each other, because the prototypes themselves often become loci around which rich dialogues begin and are sustained.

Prototyping requires the building and testing, and then re-building and re-testing, of many different, possible manifestations of something so that, eventually, only the iterations that are assessed as being the most effective remain for consideration and possible implementation at the end of the process. Educators of 11-to-18-year- old students and the students themselves need to understand that prototyping is antithetical to modes of working that call for a single plan to be executed from start to finish without diverting from the strategy that was originally articulated to guide its progression. It is a messy and unpredictable process, and is informed as much if not more by data gleaned from what happens when a given prototype fails than when it, or some aspect of it, succeeds (Lombardi, 2013: 9-11). It is NOT a linear process, but rather a cyclic, often circuitous one. It requires that a given prototype or sets of prototypes that depict or allow for the operation of specific ideas or procedures be analyzed and evaluated prior to attempting to construct the next generation of prototypes.
Challenging 11-to-18-year-old students to analyze how and why a specific prototype, or some aspect of it, failed to be perceived, or to function, or to be utilized as planned, can help them learn to engage in *failure analysis* as a means to guide and support their decision-making processes (Edmondson, 2011). Learning to determine what causal or correlational factors may have contributed to a given prototype not working as well as had been hoped helps students understand the developmental roles that failures play in processes that can eventually yield more desirable outcomes. Engaging in comparative analyses of how different prototypes were appreciated (or not) from emotional and functional perspectives can help students gain important insights about what people unlike themselves might really want and need. It can also help them better understand how these prototypes were operated, and how those who used them felt about their experiences afterwards. Students who learn to effectively analyze failures also learn how to avoid making false assumptions about what is most necessary or desirable among others whose belief systems, and ways of thinking and doing, are different from their own. In this way, learning to engage in the process of gaining knowledge from failure can help students learn to think and work empathetically.

The prototyping processes that are an integral part of designing backwards begin by envisioning and then constructing, often in rough forms, multiple, broadly informed ways to build, facilitate, actualize or do a thing, experience, procedure or activity. Ideally, designing backwards is contextualized and then guided by research data that has been gathered and analyzed from diverse primary and secondary sources, rather than by the singularly informed will of one person or group to enact what they believe to be right, or just, or a viable solution to their perception of a given problem. Prototyping processes invite the participation, sometimes repeatedly, of at least a few people who will or could be affected by the decisions to change, make, or do within the context of a given situation that affects one or more aspects of their lives (Portigal, 2013: 12-14). Because of this inherent inclusivity, prototyping processes can help build consensus between diversely constituted groups, including those who do not share the life experiences and understandings of 11-to-18-year-old students.

These processes require a high degree of real curiosity and open-mindedness among those who engage in them, as they often yield outcomes that call for something to be done differently than it has been done up to now, or that calls for the invention and implementation of something new.

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When planned and operated effectively, the prototyping processes that guide designing backwards provide a means to yield insights, apprised by multiple perspectives and belief systems, that achieve relevant, actionable effects and consequences. Teaching educators from a variety of disciplines to teach their students to design backwards - to incorporate prototyping into their decision-making processes when they are confronted with complex problems - can afford *both groups* with a conscientiously framed and guided means to productively address, and, as necessary, transform them. Designing backwards also makes use of prototyping as a practice that encourages collaboration between individuals and groups that might not otherwise have occasion to meaningfully interact with each other. As such, it can help teachers immerse their students in learning situations that afford them opportunities to build empathy for people who think, act and aspire to life and career goals very different from their own.

Operationalizing 'designing backwards' as an integrative, educational toolkit for 11-to-18-year-old students and their educators

As an integrative tool, or, more accurately, as an integrative, adaptive toolkit for education, learning to develop and operationalize the means to design backwards has the potential to bolster the efforts of educators at the middle- and high-school levels who have been challenged to teach their students to identify, contextually frame (Schön, 1984) and resolve so-called 'real-world problems'. These types of problems require that 11-to-18-year-old students learn to empathize with people unlike themselves. They tend to involve complex issues such as individual and family nutrition and wellness, emotional health, understanding macro- and micro-economic realities, gaining knowledge about how public policies affect individuals and groups, and cultivating pluralistic awareness of social and cultural identities. These types of problems also require that these students learn to embrace means of understanding, planning and doing that are *not* guided by linearly structured, predictable kinds of logic. By being immersed in learning situations led by educators who have learned to design backwards, students at the middle- and high-school levels can be challenged to re-think their perceptions about the prevailing factors, conditions and belief systems that are affecting a particular group in a specific way.

As they do this, these students can learn to engage in a process of problem-solving that allows them to, at best, develop expertise with, or at least develop a fundamental understanding of, *abductive reasoning*. Although many students enrolled in public school settings in the U.S. are introduced to inductive and deductive reasoning in math and science curricula during their middle school years (6th to 9th grades; when they are 11- to 13-years-old) (Yopp, 2009: 288), their exposure to abductive reasoning - the type that guides designing backwards - tends to be much more limited or non-existent during this period of time.

Learning to structure an argument that guarantees the truth of its conclusion (per deductive reasoning), and learning to do this so that sound evidence may be offered that something *might* be true, based on structured experience (per inductive reasoning), can and does help students reason their ways through well-structured and constrained, empirically framed problems. However, neither of these structures affords them a means to offer new insights relative to the logic presented in the arguments, or new knowledge that could be derived from inferring conclusions that best explain *why* a particular social, technological, environmental, economic or political phenomenon has been observed within a specific setting (Kolko, 2010: 16-17).

To effectively understand, much less address or attempt to affect how even a small portion of the limited factors that envelop a specific group requires a different kind of thinking than that which is informed by deductive or inductive approaches. This alternative type of thinking has to allow for the generation of ideas that stem from what can be ascertained, interpreted or derived from attempting to explain why a given situation is occurring as it does, *even if this explanation fails to account for any previously understood rationales that could justify the evolution inherent in a given chain of events.* Thinking and reasoning guided in this way by inference and intuition "is directly aided and assisted by personal experience. Yet the personal experience need not be with the specific subject matter of the…problem. The abduction itself can be driven by any design or cultural patterns that act as an argument from best explanation" (Kolko, 2010: 21).

Abductive reasoning allows individuals and groups of students to form hypotheses, which they may or may not choose to act upon, and which may or may not prove to be correct, based on what they can infer is the best explanation for the occurrence or the perception of a particular phenomenon. Students learn that people rely on both their individually and communally cultivated stores of knowledge as they attempt to form hypotheses that guide a wide variety of decisions they have to make every day. Abduction allows people, correctly or incorrectly, to choose

how they drive their cars or ride their bicycles when they encounter particular situations 'in traffic;' it affects how they select what to eat and not eat, based on their perception of how they think something new might taste or provide nourishment based on their experiences with other food items that they know are 'kind of like it'; it allows humans to operate a logic of discovery rather than proof (Lipton, 2004: 55) that can lead to new ways of knowing and thinking about the transpiration of particular situations in the world.

It is in this latter mode that abduction can afford middle- and high-school students - or financial planners, scientists or designers – a means to envision and then suggest ways to make specific aspects of the future better for affected groups living or working within problematic situations. Additionally, when students are taught to couple abductive reasoning with the prototyping processes described in more detail in the next section, they can determine whether or not what they suggested, and then attempted to invent, was a valid means to improve a particular situation on behalf of a select affected group. (Prototyping processes offer means to validate knowledge in ways that abduction does not, as prototyping allows understandings to be informed as effectively by failure as they are by success.)

Facilitating collaborative, idea-generation and analysis processes through prototyping and problem-framing with pre-collegiate students

The thinking that guides designing backwards suggests that 11-to-18- year-old students can learn to

1. utilize their analyses of factors and conditions that frame a specific problematic situation to
2. guide the synthesis of particular 'bits of knowledge' gleaned from these analyses to
3. suggest new ways for the affected group to improve their circumstances within that situation.

In turn, these 'new ways' to help an affected group improve their circumstances can be realized as *prototypes*. These can take many forms, and include but are not limited to artifacts. They might emerge from the designing backwards process as new procedures or protocols for guiding specific activities, or new ways of doing, making or communicating, or new products or systems that might help the affected group ameliorate particular aspects of the negative situation in which they are or are likely to be immersed.

The process of developing prototypes can yield several benefits to 11-to-18-year-old students and those who teach them. Among them are the following that can help these students begin to develop and hone the habits of mind that are necessary for them to become more adept *critical thinkers*:

- Prototypes are developed in an iterative series of actions or steps that allow for the consideration of many variables – ease of use, socio-cultural perception, cost, feasibility, sustainability - and this tends to dissuade students from 'falling in love with their first ideas';

- The fact that prototypes require ideas to be made manifest in some type of physical form - as a diagram, a crude model or plan, a set of instructions—requires students to 'show-and-tell' how key features of their prototypes would work (Zaki - Wurfel, 2009: 3-5);

- Prototyping provides a dynamic yet *hypothetical* means for those in a given affected group struggling within a particular problematic situation to participate in dialogues with each other that are focused on how implementing a specific course of action, or 'solution', as represented by the prototype, might or might not benefit them;

- Prototyping enables those outside the affected group to engage in dialogues with those who are within it about the ramifications of actions in the simulated, or (again) *hypothetical* realm of the prototype *in an inclusive rather than exclusive discussion;*

- Because prototypes are developed in iterative steps, each phase of one's development can provide the means to *test and assess* its particular attributes and features - students can gain crucial insights during these evaluative processes regardless of whether these attributes or features succeed or fail;

- When a prototype, or one of its key components or characteristics, is deemed a failure, an analysis of 'what caused it to fail' can yield students the insight(s) necessary to develop its next iteration in a manner that addresses whatever it was that caused the failure to occur;

- Because prototypes can and should be made quickly and without overt attention to detail or 'final polish', students learn to use and perceive them as tools for generating ideas, rather than end-products that they have worked too hard to make to want to critically analyze, much less discard in favor of something new.

Circumstantial issues	These have more direct, micro-level types of influence on how a particular situation evolves. Examples include how specific groups choose to signify social class distinctions or aspirations, political beliefs or sexual attitudes by possessing and operating distinct types of material goods or utilizing specific types of services, and how these choices affect perceptions and patterns of consumption in given areas among certain populations.
Actors	They are represented in concept maps such as the one articulated in Figure 1 by personas whose behaviors are hypothetically guided by particular sets of social, cultural, economic and political beliefs. Given their respective biases, the manner in which they act within specific kinds of situations can be accounted for visually within a given concept map's structure.
Conditional factors	These encompass socio-economic, political, technological and environmental conditions that can be cited as having broad causal or correlational influence. Examples include regular access to electricity and the Internet, amount of rainfall per year, access to regular employment opportunities at fair wages, and the type of government in power in a given region.
Networks	These can also be organized within a concept map such as the one that is depicted in Figure 1 whenever students, their project collaborators and their instructors deem it necessary to organize a given group or groups of factors, issues or actors together in a more systemic way. Doing this enables the collective influence of a network to be critically examined in light of how it has affected, is affecting and could potentially affect other networks or individual factors, issues and actors within and around a given negative situation.

Table 1. The four types of variables that 'frame', or envelop, a given problematic situation

The process of developing prototypes is also a means to gather and analyze evidence-based data gleaned from observing and engaging in dialogue with at least some of the people who will actually use, experience or perceive whatever product, service, procedure, or new way of doing, making, or communicating has been created for them in the form(s) of a prototype. A student or team of students should only begin to attempt to create an initial prototype after he/she/they have attempted to understand the various *circumstantial issues, actors, conditional factors and networks* that contextually surround, or frame, a given negative situation (Gibson and Owens, 2014). These four variables are briefly articulated in Table 1.

Figure 1, appearing below, depicts how specific examples of the four variables described in Table 1 can be visually articulated to help educators and their students examining a particular situation or set of circumstances better understand how these variables affect it. In this sample case, the situation involves parents in the U.S. choosing not vaccinate their children against measles, mumps and rubella (MMR). (The American Center for Disease Control and Prevention reported 644 cases of measles in the U.S. in 2014, and more than 15% occurred in people over 18 years of age who had come in contact with children who had not been vaccinated against the disease) (Bruni, 2015).

The situation depicted here is framed, or enveloped, by a complex array of variables that are arranged into the four, categorically organized 'arrow areas', each of which corresponds to the four variables described in Table 1. This depiction is not intended to include the entire array of variables that envelop this situation.

Rather, it serves as a starting point from which pre-collegiate educators and their students can glean information that can, in turn, begin to spark hypotheses about how this situation, or at least some of the aspects of the lives of those who live and work within it, might be improved. Subsequently, these hypotheses can be used to inform and guide the iterative development of prototypes, which can be articulated and operated in many ways. These new ways of doing or making, or new methods and procedures, or new inventions manifest as artifacts or systems of artifacts, can be critically discussed, tested and revised in multiple cycles (see Figure 2 below). The goal of this process, which (again) has long been an essential tenet of the pedagogic approaches that guide design, is to help pre-collegiate educators and their students learn to think in ways that allow them to empathetically envision and then guide desirable, appropriate transformations.

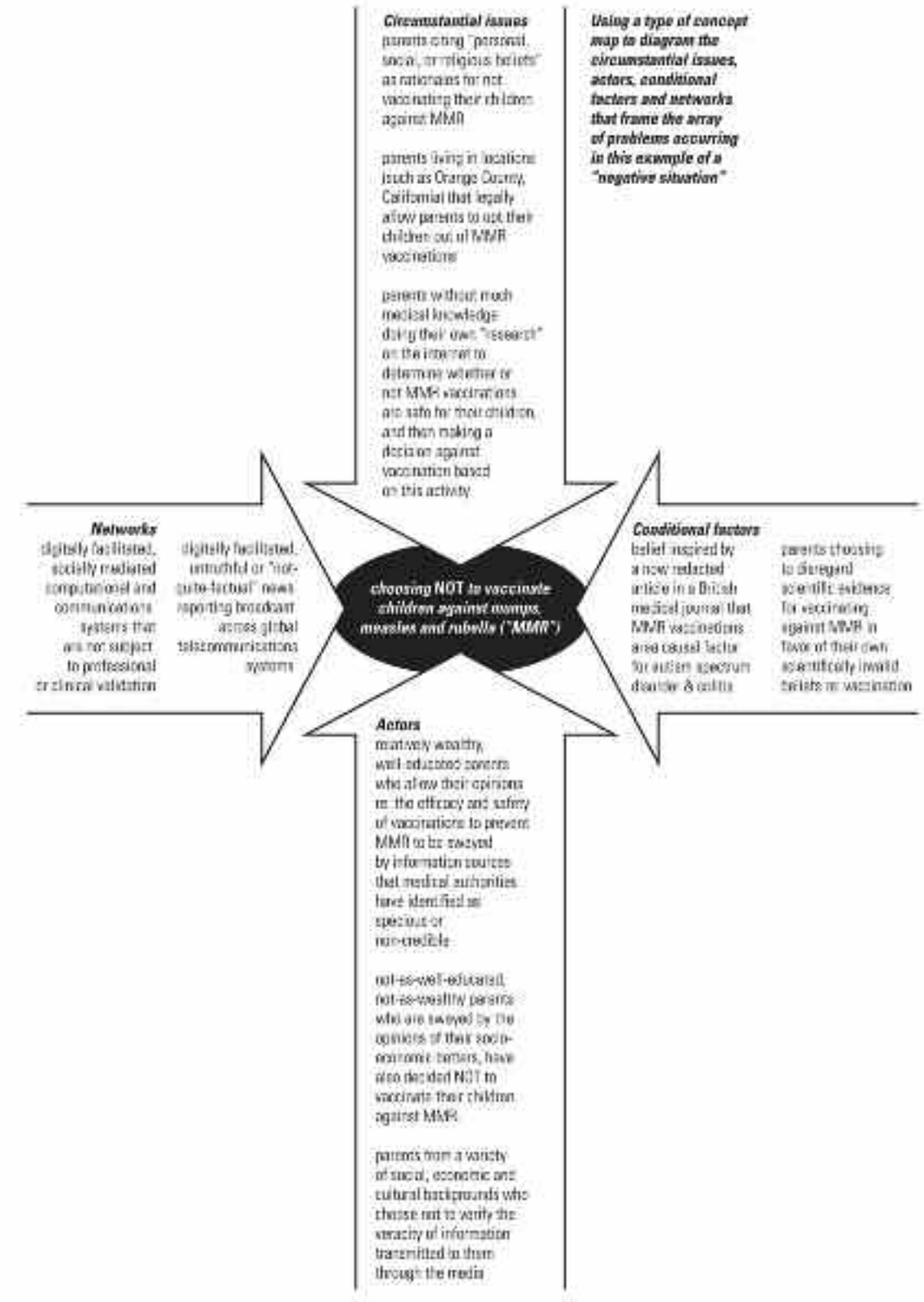

Figure 1. Using a simple diagram to depict the circumstantial issues, actors, conditional factors, and networks that frame/envelop a given problematic situation.

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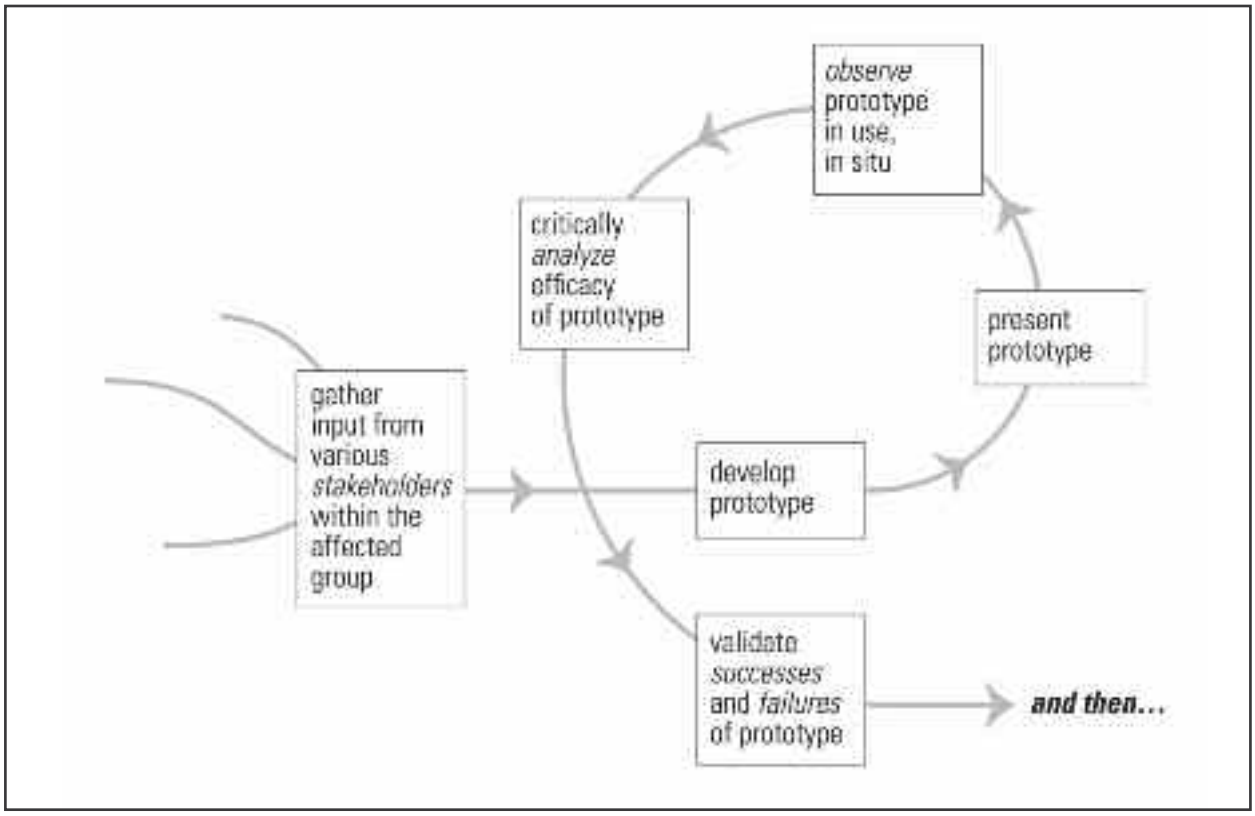

Figure 2. A depiction of phase one of the iterative, inclusive process of prototyping

Engaging in the creation and testing of prototypes can also equip students with a dynamic means to a gather the evidence and rationales necessary to help them advocate for the pursuit of particular courses of action and against others. It can also facilitate this in ways that allow those who could or should be affected by these actions - a given affected group enveloped within a particular problematic situation - to be directly involved in decision-making processes that have the potential to change some aspect(s) of their lives. As depicted in Figure 2, prototyping is an iterative, cyclic process that calls for the creation of something that emerges from one or more hypotheses about what could or should be done to ameliorate a given undesirable situation on behalf of a well-defined group of users, or audience, or experiencers.

Prototyping begins after the content depicted in a diagram like the one shown in Figure 1 has been analyzed and hypothesized about.

Allowing members of a group who are situationally affected by given sets of circumstantial issues, conditional factors, actors and networks to participate in the processes of conceptual diagramming and prototyping gives them an active role in decision-making processes that impact them. It also helps ensure that whatever is developed and tested during prototyping is analyzed and evaluated from multiple perspectives, which encourages a more diverse array of options to be considered.

Prototyping processes require as much time and attention to determining what *is not* working and why as is required to determine what is working and why. Because they are made to be tested to the point where they may break or fail, and then evaluated and openly discussed and critically analyzed, prototypes help students gain knowledge about how to marry abductive reasoning, which yields ways of *knowing*, with assessment methods that yield ways of validating what has come to be known. In this manner, prototyping yields evidence that can be used to support or discourage particular types of decisions, and the strategies and activities that emerge from them. Once a prototype's efficacy, or lack thereof, has been validated, the process begins again, as depicted in Figure 3, as a means to inform and guide the creation of the next prototype. These processes can continue until those involved reach a consensus about which prototype, or which *version* of which prototype, should be made, implemented or distributed.

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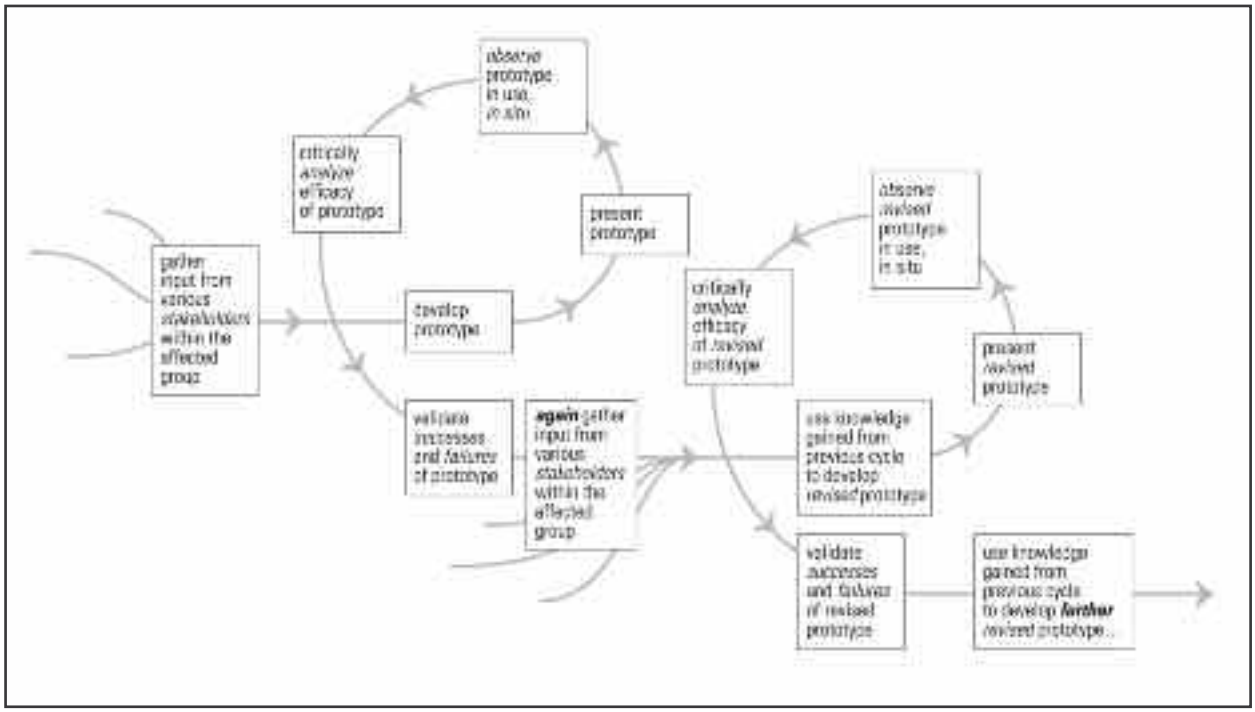

Figure 3. A depiction of phase two of the iterative, inclusive process of prototyping

What utilizing the process of designing backwards can look like in learning situations involving undergraduate and pre-collegiate students.

Between September of 2013 and May of 2015, 19 undergraduate communication design students at The University of North Texas (UNT) worked with a group of six local middle school and eight high school students during an interactive design project guided by the 'designing backwards' process. The middle- and high-school students had been diagnosed with one of two chronic diseases, or a clinically documented behavioral or substance abuse disorder. The intent of this interactive design project was to develop prototypes for mobile apps or other interactive experiences that could help these students and their families better manage their physiological and psychological conditions. Additionally, three middle school nurses from the Denton, Texas, U.S.A. Independent School District were interviewed on one occasion to inform the development of paper prototypes for the mobile apps and interactive experiences described below, and depicted in Figures 5 and 6. At least one parent of each pre-collegiate student was interviewed during the paper-prototyping process as well.

This project began with individual or pairs of the undergraduate design students conducting two to three one-on-one and then small-group (two to four participants) interviews of approximately 20 minutes each with the middle- and high-school students. The information the undergraduate design students gleaned from these interviews helped them populate versions of the envelopment/framing diagrams depicted in Figure 1. These diagrams also helped each undergraduate student work with one to two middle-or high-school student partners to initiate the 'designing backwards' process. Key insights and understandings about how and how not to address particular issues and concerns per disease or disorder were identified as design criteria at this time.

As these teams of undergraduate-plus-pre-collegiate students discussed successive iterations of their envelopment/framing diagrams, these conversations informed the development of a series of wireframe diagrams (Figure 4). These were then used to plan the design and functionalities of paper prototypes (Figures 5 and 6) of potential apps and interactive experiences that could be roughly configured for testing and assessment. The manually executed, wireframe sketches and paper prototypes of the types depicted in Figures 4-6 could be quickly generated and altered and used in usability testing sessions with the pre-collegiate students. These sketches and prototypes exist primarily to garner feedback and inform the decision-making necessary to further develop a

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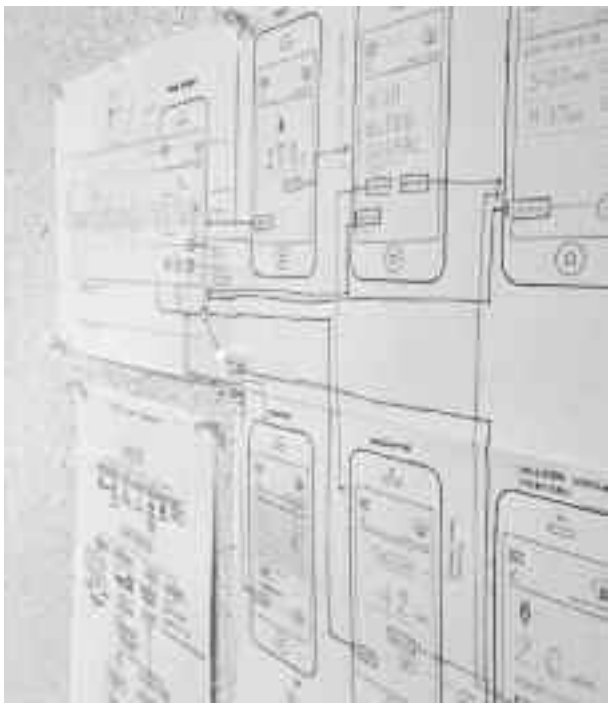

Figure 4. Manually generated, wireframe 'roughs' of a prototype for a mobile app intended to assist newly diagnosed middle school diabetics with their daily needs.

Figure 5. A 'rough' of a paper prototype designed to facilitate usability testing of a mobile app hypothetically intended for joint use by middle- and high school nurses, parents and students regarding sexual issues.

given idea. They are shown here to offer concrete evidence that prototypes created quickly - in a matter of a few hours - and without great attention to detail can yield useful information to project developers and would-be 'problem-solvers'.

The various stakeholders in this project strove to develop these prototypes to the point where they could help pre-collegiate students in north Texas more effectively monitor their physiological and psychological conditions on a daily basis. Secondary goals, such as live, two-way data sharing with family members and healthcare providers, emerged and were addressed as the project developed. A tertiary goal was to ensure that these prototypes would work in ways that prevented the pre-collegiate students from feeling stigmatized because of their need to document and manage their various diseases and disorders.

Conclusion

Gathering and analyzing data in ways that result in the creation of evidence that can in turn be operationalized to inform how something is managed, made and communicated is one of the primary benefits of engaging in designing backwards. The situational diagramming and prototyping processes that guide it can begin on a relatively small scale and progress quickly. Designing backwards also evolves in ways that allow 11-to-18-year-old students to easily glean evidence from these processes of 'build, test, assess, re-build, re-test, re-assess…' that can effectively inform their decision-making processes about why and how to invent a new thing, procedure, experience or environment. Asking these students to work with individuals from an affected group to co-construct a succession of prototypes as a means to do this allows students to gain first-hand knowledge about how people unlike themselves think and act. Asking these students to evaluate how people from a given affected group perceive, act within or utilize a specific prototype also helps them learn to trust what they can analyze and interpret from engaging in this process as useful, usable knowledge. This is quite different than predominantly trusting their often narrowly informed assumptions about what is relevant, right to do or *not* do, or just. Designing backwards can also help these students learn the value of appreciating and analyzing endeavors, or aspects of them, that *fail* to operate or yield results as planned, as a means to determine what about them could be altered in ways that might eventually be deemed successful.

Figure 6. The testing process of this prototype allows those involved - designers, teachers, nurses and students - to quickly operate and evaluate several different scenarios of use.

Figure 7. As the prototyping process evolves, slightly higher fidelity versions are created to provide all project stakeholders and designers (who may be stakeholders themselves) with a means to facilitate broader, more critically deep conversations.

To better understand the process-based activities that inform designing backwards, it can be helpful to describe how they ought *not* to transpire. They should avoid beginning with a pre-conceived idea of what should result from a given undertaking that involves design (i.e., an app, a type of product, environment or interface, a specific type of system, or version of a procedure). Designing backwards is also *not* a means to guide the creation, manufacture and implementation of artifacts and systems of artifacts that may be deemed aesthetically pleasing or beautiful, although these do sometimes result from this process. It is presented here to provide today's middle- and high-school students - tomorrow's practitioners - with a means to think and then act in ways that will allow them to contribute to the development and implementation of ideas that effectively and relevantly account for the needs and desires of others.

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