# Adaptive Products:
# Designing for Evolution Through Use

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## Introduction

On the website for any given design firm you can find a diagram that shows their process. There are differences in the number of steps and the words they use, but invariably it begins with research and ends with releasing a product. Starting with research is important because we as designers are solving other people's problems. We inform product decisions by immersing ourselves in the appropriate context, researching people's lives, and testing our ideas. If a deep focus on the intended user is maintained then the product can end up being useful, usable, and desirable. Unfortunately, it can also lose those qualities over time; people change, context shifts, and fashion flops. When products are put to unexpected uses, new demands are placed on them, and they become obsolete. Despite good intentions designers focus too much on today and neglect to consider how products might evolve in the future. Architect Christopher Alexander contrasts this to nature, where you have "continuous very-small-feedback-loop adaptation going on, which is why things get to be harmonious . . . If it wasn't for the time dimension, it wouldn't happen."[1] Just as there is no end to the process in the natural world, creating products that evolve will require those process diagrams to be updated, stretched, and looped.

I discovered firsthand how the changing needs of people can diminish the usefulness of a product through an organization and website called Moped Army. I co-founded this group of moped enthusiasts nearly a decade ago to bring together people with a shared interest in these vehicles, rarified in the United States because of a brief importation period. To organize the group I built a website to allow for communication amongst members and

[1] Stewart Brand, *How Buildings Learn: What happens after they're built* (London: Penguin Books Ltd., 1995), 21.

act as an information resource for all moped riders. What began locally expanded over time and now includes hundreds of people in official branches and thousands of regular website visitors. As the organization evolved it continually outgrew the website necessitating four complete redesigns from scratch. Each time, a new design process was initiated; a reframing of the problem based on new needs, a changed situation, and expanded goals.

Today, the website is once again outdated and causing unexpected problems for the growth and health of the organization. Local branches are feeling constrained by outdated structures, members are unable to communicate in ways they desire, and visitors lack a way to accurately express their identity and role in the community. A small group of moped riders have completely abandoned the site, creating their own because it could not flexibly accommodate what they desired. The idea of starting the design process again is disheartening, because the organization is growing and changing faster than ever a redesign like the others would just be playing catch up.

## The Need for Product Evolution

I am interested in how products can evolve as people use them. To investigate this idea I will explore three concepts: product, to understand what is changing, adaptation to learn how evolution happens, and autonomy to appreciate people's individual and collective involvement in this process. I plan to look at what types of products are being designed today, why people need the freedom to modify them, and how they can change over time. Throughout, I will be examining the changing role of the designer and how product evolution alters the relationship between designers and users.

If there is a single phrase that dominates the history of design it is "form follows function,"[2] coined by Architect Louis Sullivan in 1896 and popularized in the early 20th century modernist movement. This maxim has served designers well but offers little insight into the social nature of form. Winston Churchill also remarked that "We shape our buildings, and afterwards they shape us."[3] He was observing how the cramped Chamber of the House of Commons did more than its function of holding Parliament members; its form changed the way they interacted with each other. Philosopher of technology Peter-Paul Verbeek, author of *What Things Do*, believes that products also "profoundly influence the behavior and experiences of users."[4] He describes how products mediate our interactions with the world, transforming the way it is perceived and affecting the ways we can act within it. Perhaps it is also true that we use our products, and afterwards they use us. Because products shape our lives they need to be designed with more than just function in mind. What happens when functional needs change? What if a product's influence is undesirable? Stewart Brand, author *of How Buildings Learn*, proposes a modification to Churchill: "First we shape our buildings, then they shape us, then we shape them again—ad infinitum. Function reforms form, perpetually."[5] But not all products are so easily reshaped because usually the official role of people is to have needs, purchase the product, and use it in the way it was designed. In reality people always try to modify and adapt products to changing needs and situations. Musician Brian Eno believes "an important aspect of design is the degree to which the object involves you in its own completion."[6] That sort of

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[2] Brand, 3.
[3] Ibid.
[4] Peter-Paul Verbeek, "Materializing Morality: Design Ethics and Technological Mediation," *Science, Technology and Human Values*, Vol. 31 no. 3 (May 2006): 361.
[5] Brand, 3.
[6] Brand, 11.

involvement is one way products can evolve. Economist Eric Von Hippel describes another approach to product evolution in his book, *Democratizing Innovation*. His research focuses on people who make modifications to products and he argues that companies can discover unmet needs by observing how and why people adapt products. This points towards product evolution happening on multiple levels: first, people can adapt individual products for their own situations, and then designers can evolve the "official" version by learning from these adaptations. All evolution ultimately happens after what is considered the normal design process, after the product has been released into the world. This presents a new challenge for designers as it calls for an ongoing, longer-term engagement with a product and the people using it. It also transfers some of the design control into the hands of the user, requiring a humble acceptance that people using a product deserve to help shape it over time.

## Redefining Products

What are we talking about anyway when we talk about products? It used to be easier to answer that question than it is today. One used to be able to say that a product was physical, discrete, and mass produced. One could point to it, or hold in one's hands, take it apart and see how it worked. It was fairly easy to evaluate what it did, how it functioned, and what it was for. Designers were defined by the end result of their work and given titles such as industrial or graphic designer. The definition of a product has expanded though, and as it has changed so have the challenges and responsibilities for designers. Today there are interaction designers, information designers, service designers, and numerous other titles; each of these terms attempts to deal with the changing nature of products. Some of the factors driving these changes are technological, like the miniaturization of

electronics and ubiquity of the Internet. Others include social and economic influences such as the rise of globalization and multinational corporations. Ultimately, products are shaped by a multitude of forces including technological, cultural, market, and legal factors; they affect how products are formed, what they are designed to do, and how we think about and use them. These forces shape the very definition of a product, and they are constantly changing.

But in what ways have products themselves changed? One of the most fundamental shifts involves the widespread embedding of computation. Today, only the most simplistic products are without some form of electronic circuitry and even common household objects, from toothbrushes, to pictures frames, to running shoes may have a computational component. Electronics are found more often outside of traditional computers than within. The significance of this change is not only the use of new materials, but also the way our relationships to these products have changed. Their range of functional possibility is no longer directly observable in their form, taking them apart will not yield an understanding of how they work. These products may be capable of sensing, responding, or acting in unexpected ways. Maybe your toothbrush can count the amount of time you spend brushing, your picture frame can change its own photo, or your running shoes can tell you about your health. The possibilities will only expand as more products embed wireless Internet access along with computational abilities. This decoupling of functional possibility from physical form lets products behave in new and unexpected ways.

Embedded computation augments the possibilities of tangible objects but we also routinely use products without any physical form. Software products significantly expand the definition of a product by removing some of the original descriptors. The physical constraint is obviously gone but

perhaps even more significant is that software is no longer discrete. A software product is conceived in versions that we install as upgrades with an assumed notion of continuity between installments. We expect that the product will be modified over time to fix bugs, provide new features, and run better. These upgrades are not always stand-alone, acting as patches and updates rather than whole new products. On the web this notion is taken even further as one is always connected to the latest version of a website. Changes made by designers and programmers are reflected automatically and might occur many times a day as necessary. The web renders software versioning and upgrades obsolete, establishing constant change as a product norm rather than an exception.

The possibility for dynamic change has also removed the criterion that products must be mass-produced. On the web it is trivial to serve different variations to different audiences, or even individuals. Take for example Amazon.com, who generate their website in real-time based on items you have viewed or purchased. Individualization is a rising trend and one can see the effects seeping into the physical world as well. Companies are offering print on demand books, ultra-customizable cars, and shoes you can design yourself. Tools of mass production such as the assembly line are being reconfigured to efficiently produce not one size fits all products, but customizations with enough variability that many choices are truly unique. Today it is not only small companies with low throughput offering personalized products—mass customization is moving from a luxury to an expectation. Surely the web is influencing some of these changes towards dynamic production, but there is more under the surface than Internet trickle down. Our world is increasingly global, with people being influenced by a wide variety of ideas and cultures. There are valid critiques that globalization brings homogenization but alongside and despite that there is a

purposeful and individualized blending of cultures occurring. For better or worse we now have the ability to mix and match cultural influences from around the world to create a unique combination of our own. The companies that drive the global economy are feeling pressure to provide tailored solutions, not only to individual markets but also specific individuals. Our idea of a product is still physical, discrete, and mass produced but now also includes the intangible, constantly changing, and highly personalized.

Another change to the way we think of products is their increasing fusion with the services that surround and support them. Sometimes products and services stand-alone but often they rely on each other. When someone wants to accomplish a particular activity or complete a particular goal they might use numerous products and services in the process. The lines between the two are blurred in use and people may not readily distinguish between them. When something goes wrong (or right) it may be hard to attribute it only to the service or the product, which in turn affects the ways that people think about and define what a product is. Consider the case of a digital camera, which allows photos to be taken and viewed on a built-in screen. Generally people want to do more with a photo than view it on the camera and store it on their hard drive. So they turn to an ecology of other products and services that are, in the eyes of the user, integral to the usefulness of the camera. There are a myriad of activities associated with photos. People want to print and view them at home, take them to in-store printing kiosks, upload for Internet based printing, send them to friends, and share them on websites, they manipulate, edit, view, and archive them. They make photos into videos, convert them into calendars and display them nearly everywhere at home, work, and in public. After a photo is taken all sorts of products and services are needed to allow for these ancillary actions,

but who offers these additional services and how are they related to products? Are they conceived of and designed by the same people, or do third parties offer them? How well do products integrate with related services? These questions are fundamental to the changing definition of products and directly relate to the quality of experiences people have when using them. It is this focus on experience that marks another change in how products are defined and designed. If the combinatorial use of products and services is unsatisfactory the distinctions between them do not matter; to design for a good experience the focus must be on the seamless integration of the two.

When products and services are intertwined in a symbiotic way they become one in use. A good example of this is the Apple iPod music player and the iTunes software and music store. This is a product/service system integrating three separate components: hardware, software, and the web. Each component combines a consistent design language with a tight coupling of capabilities. The iPod for example is designed as only a music player, and relies on the iTunes software for all playlist management and configuration. This simplifies the interface and moves the more complicated functions to an environment where they can be more easily handled. In turn, iTunes is closely integrated with the online music store, seamlessly allowing people to purchase music and transfer it to their iPod. Products of any significant complexity are made up of many components and thus can always be thought of as a system, an interconnected set of parts that work together to form a whole. A product/service system is really just a higher order product with the component parts being wholly formed products and services. In the same way that people may not consider the components of a product while using it, people may not differentiate between the various parts of a product/service system. It is the interactions that people have with the system, the holistic experience of use, that end up becoming the product. Designers are still

crafting the form of individual components but are focused on how they interact with people and the overall system.

By any measure, the definition of a product is less clear now than in the past and even within the design community there are opposing definitions. This variety of viewpoints is a normal consequence of changes in technology and society, which have in turn changed our relationship to products. Is a product defined by its form, its physical or virtual representation? By our individual customization and recombination of those forms? Or is it defined through use, through the interactions and experiences that people have through it? Stewart Brand has pointed out the beautiful plurality found in the word "building," which refers to "the action of the verb BUILD" and "that which is built." Although we don't have a single term to so elegantly combine the definitions of a product, we can take from it the lesson that use and form are always irrevocably combined.

The definition of a product has evolved but how can an individual product change over time? If a product is partially defined through use then what is the role of the designer in shaping that use? Can a designer dictate evolution through form, or is something more complicated happening when people use products?

## The Relationship Between People and Products

You may have noticed that using a new product can change the way you do things. Not only the new functional capabilities it provides, but the other things that happen because of it. For example, when I made the switch from using a landline telephone to a cell phone it not only allowed me to make calls from anywhere, it changed the nature and content of those calls. I am now more likely to talk on the phone while doing something else, more likely to answer even when I am too busy to talk, and the conversations I

have tend to be in the evening when the calls do not count against the total minutes available on my plan. Sociologist Bruno Latour has pointed out "what humans do is in many cases co-shaped by the things they use."[7] The cell phone is not forcing me to make these changes to the way I talk to friends and family, but it is influencing me. Latour developed a theory of how products, along with personal intention and social structures, affect people's actions. He calls this influence the "script" of a product and similar to how a script for a play gives particular directions for an actor to perform, a product prescribes particular actions for people who use it. A simple example he uses to illustrate this idea is a hotel room key with a bulky, heavy key ring. If a hotel manager wants guests to return the key when they leave their room she could post a sign requesting that action, but it might be overlooked or forgotten. Instead, the script for the desired action is embedded in the thing itself; the key is simply too inconvenient for the guest to take with them, almost "asking" to be returned to the front desk. Clearly a hotel guest could choose to defy the script, the key ring does not wield real control over their actions, rather, "one could say that specific actions are invited while others are inhibited. The scripts of artifacts suggest specific actions and discourage others."[8] Scripts are a way to think about how products do things above and beyond their functionality, how they mediate and co-shape actions of the people using them.

Products not only influence our actions in the world, they can also transform the way we perceive it. For example, a thermometer takes temperature, something we can directly perceive, and converts it into a particular value we must interpret. This abstract representation tells us something about the world but in a manner very different from directly

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[7] Verbeek, *Materializing Morality*, 366.
[8] Ibid., 367.

experiencing it. More profoundly, some products make things in the world visible that are otherwise not directly observable. Medical imaging give us new ways of seeing the body, geographic information systems represent the city and its people in an aggregated manner, and charts and graphs of all kind visualize the hidden data of financial networks. These imaging techniques, and the products that implement them, "help to determine how reality can be present for and interpreted by people." They "help to shape what counts as 'real'," [9] by giving us new ways to see the world. Whenever a product mediates our perception a type of transformation occurs. Philosopher Don Ihde talks about this in terms of amplification and reduction, that "mediating technologies amplify specific aspects of reality while reducing other aspects." [10] For example, when looking at a skin sample under a high powered microscope the surrounding context and most things that are recognizable to the untrained eye are lost, but cellular patterns used to diagnose disease become visible. Using one of these products does not permanently change our perception of reality, rather they provide "specific forms of access to reality." [11] Ihde refers to this as "technological intentionality", saying that "technologies have 'intension,' they are not neutral instruments but play an active role in the relationship between humans and their world." Again, products are not simply functional, they co-shape our perception of the world as well as our actions within it.

How do products get these scripts and intentionalities? According to Latour designers are the ones who "inscribe" a program of action, either implicitly or explicitly, into products. Inscription acts a type of "delegation" meaning that specific tasks are delegated to products for them to perform.

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[9] Ibid., 366.
[10] Ibid., 365.
[11] Peter-Paul Verbeek, *What Things Do: Philosophical Reflections on Technology, Agency, and Design* (University Park: Penn State University Press, 2005), 133.

Verbeek notes that "delegation makes possible a curious combination of presence and absence: an absent agent can have an effect on human behavior in the here and now."[12] In the example of the hotel key ring the manger no longer needs to be present to remind guests to return the key, this job has been delegated to the key ring itself. Another example of delegation given by Latour is a door-spring. "Humans delegate to the door-spring the task of shutting the door after somebody opened it; they inscribe the program of action 'close the door if it is open' in the spring."[13] In turn, the design of the door-spring encourages a particular way of using the door; if it is a strong spring then you need to push the door open slowly so that it does not snap back in your face. Products, as it were, "can implicitly supply their own user's manuals."[14] A different type of delegation can be found in a hydraulic door pull, which is "especially clever [in] its way of extracting energy from each unwilling, unwitting passerby."[15] Here, the door pull delegates to the people using it the task of providing enough energy to close the door tightly.

What things do however is not always so purposefully designed. On top of functionality, on top of delegated scripts and intentionalities, are unexpected consequences. One can "observe more in artifacts than only what is delegated to them, or inscribed in them, by humans. In many cases, that is, things do much more than what humans intend."[16] Using a product can lead to unintended consequences, sometimes positive but also at times undesirable. Examples of products that unintentionally exclude less-abled people are numerous, from revolving doors that keep out wheelchairs to websites that cannot be used with screen readers for the blind. Other less

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[12] Ibid., 160.
[13] Ibid.
[14] Ibid.
[15] Ibid., 170.
[16] Ibid.

obvious consequences can be found in my earlier cell phone example. How are family relationships changed when everyone has their own phone instead of sharing one in the home? Does being able to always reach someone affect the amount of time you spend physically collocated? What are the long-term effects of cell phone signals on human health?

Unintended consequences raise profound ethical questions for designers, who are responsible for the scripts and intentionalities of products regardless of whether or not they deliberately inscribe them. Ethically, it is not enough for designers to concern themselves only with a product's stated function. It may well be useful and usable when evaluated based on goal completion, but what of the many ways it may mediate a person's relationship with the world? It may be desirable today, but will its consequences be the same tomorrow? Verbeek believes that the mediating role of products makes design "an inherently moral activity,"[17] that designers "materialize morality" in the scripts and intentionalities of products. Unfortunately, this is usually done implicitly with designers focusing on specific functionalities and not "explicitly aiming to influence the actions and behavior of users,"[18] if considered at all it is usually in an evaluative way after a product is released. These considerations need to be consciously integrated into the design process itself. Considering these issues is complicated because "scripts transcend functionality: they form a surplus to it, which occurs once the technology is functioning."[19] A designer's work happens before a product is put to functional use in the real world. If products shape the actions and perceptions of people during use, then how can a designer know what types of mediations will occur? Additionally, people may not use a product in the

[17] Verbeek, *Materializing Morality*, 368.
[18] Ibid., 369.
[19] Ibid., 362.

way a designer intended, they may not "subscribe to the inscriptions."[20] People can simply refuse to use a product, "or use it selectively and even in novel and unexpected ways."[21] Depending on different contexts a product can even take on multiple identities and be interpreted in very different ways.

Ihde uses the term "multistability" to describe the phenomenon of one product being used successfully in multiple different ways based on context. The word implies that products "can have different meanings in different contexts, but also that specific goals can be technologically realized in different ways by a range of artifacts."[22] Verbeek uses the telephone and typewriter as examples of multistability since they were "not developed as communication and writing technologies but as equipment for the blind and hard of hearing to help those individuals hear and write."[23] The formation of a new stable state for a product is dependent on the original inscriptions put in place by a designer, the interpretation of the product by a user, and on the form of the product itself, "which can evoke emergent forms of mediation."[24] How does the concept of multistability fit in it with design being a moral activity? Alternative stable states are so context dependent that designers may have trouble anticipating them. Should designers encourage or discourage alternative uses of a product? Multistability reinforces the idea that products are only defined through actual use, which happens in varied and changing contexts; they must be "interpreted and appropriated by their users"[25] before they are identified as being used "for doing something,"[26] thus their mediating influence, their scripts and technological intentionalities, are

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[20] Verbeek, *What Things Do*, 161.
[21] Ibid.
[22] Ibid., 136.
[23] Verbeek, *Materializing Morality*, 365.
[24] Ibid., 372.
[25] Ibid., 371.
[26] Ibid.

dependent on these appropriations. Products are always multistable, but usually in a less dramatic manner than the telephone and typewriter examples. Nearly every use of a product exists in a slightly different context, and these are altered all the time as people, situations, and society change. Perhaps then the ethical challenge for design is not to inscribe the "proper" set of mediations into a product, for when "human actions are explicitly and consciously steered with the help of technology"[27] one can justifiably be concerned about a loss of personal autonomy and fear of a technocracy. Instead, designers can encourage and enhance the multistability of a product. Although they cannot predict how it will be interpreted and appropriated they can provide flexibility to allow for various possible definitions. By allowing and encouraging users to rewrite or edit a product's script designers give people more autonomy over how products mediate their actions and perception of the world.

## Designing for Adaptation

Products that allow people to adapt them to new stable states, by giving them the freedom to alter the script of a product, require a significant change to the design process. Traditionally, designers have acted as delegators, researching functional needs and synthesizing them into the form a product. What they design normally has intended users, a particular script, set technological intentionalities, and a defined form. However, if products are to evolve through use, people will need the freedom to change each of these variables. How can designers allow for this kind of increased involvement and how does it change their role in the product development process? Given that designers can't control how people will use a product

[27] Ibid., 369.

they may be inclined to continue their jobs as usual, hoping that people will use products as they intend and not worrying too much about it. This is an irresponsible approach for two reasons: if the products they design can not evolve they will become less useful over time, and if people are not given the freedom to make changes they will be unable to avoid undesirable mediations and consequences. The first reason speaks directly to the traditional requirement for designers to provide a useful and usable product that meets set functionality. The second relates to an expanded view of design ethics that considers all the effects and influences a product may have. All products are predictions, and "All predictions are wrong. There's no escape from this grim syllogism, but it can be softened. [Products] can be designed so it doesn't matter when they're wrong."[28] While designers cannot anticipate all future scenarios they can do their best and allow people the freedom to adjust things as needed.

Scenario planning is a powerful tool to help designers predict how a product will mediate actions and influence people. Designers already use scenarios to provide examples of how products can be used, but usually as demonstrations showing situations that perfectly align with product functionality. When scenario planning is used as a decision making tool it can lead to more versatile products by asking "what if" at various points in an imaginary future; the product is "treated as a strategy rather than just a plan."[29] Designers should work with stakeholders to create scenarios three to ten years in the future to foresee problems and situations outside of what they know from user research. In this way scenario planning can overcome the limitations of user-centered design that "over-responds to the immediate

[28] Brand, 178.
[29] Ibid.

needs of the immediate users, leaving future users out of the picture,"[30] most products today are optimized for the present, and unable to adapt well to the future. By developing divergent scenarios of future possibilities designers can build a strategy for accommodating various types of change.

An evolutionary strategy must be coupled with a product that is flexible enough to allow for future adaptation, yet formed enough to work "out of the box." Architect Frank Duffy once said, "there isn't such a thing as a building . . . A building properly conceived is several layers of longevity of built components."[31] In his writings on adaptive architecture Brand expands on Duffy's idea to develop six general purpose "layers of change" for any building. These layers conceptualize a building not as a monolithic structure but a system of interconnected components, each layer is able to change and evolve at a different speed while maintaining a cohesive whole. Since products can also be thought of as systems, the layers are a useful way of thinking about product evolution as well. Here are the layers of change, from slowest to fastest: [32]

> **Site:** The geographical setting . . . the legally defined lot, whose boundaries and context outlast generations of ephemeral buildings.
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> **Structure:** The foundation and load bearing elements . . . perilous and expensive to change . . . these *are* the building.
>
> **Skin:** Exterior surfaces . . . keep up with fashion or technology . . . repair.
>
> **Services:** These are the working guts of a building . . . wiring . . . plumbing . . . HVAC . . . elevators and escalators. They wear out or

[30] Ibid., 181.
[31] Ibid., 12.
[32] Verbeek, *What Things Do*, 13.

obsolesce . . . Many buildings are demolished early if their outdated systems are too deeply embedded to replace easily.

**Space Plan:** The interior layout—where walls, ceilings, floors, and doors go.

**Stuff:** Chairs, desks, phones, pictures . . . all the things that twitch around daily to monthly.

Imagine what each of these layers could represent when mapped to a particular product. To briefly illustrate this idea the following list uses the layers to examine the Apple iPod and iTunes product/service system mentioned earlier:

**Site:** computer integration, URL, sound

**Structure:** docking port, headphone jack, scroll wheel, screen

**Skin:** color, materials, headphones, graphical user interface

**Services:** cabling, disk dive, song formats, software architecture

**Space Plan:** navigational menus, song information, display windows

**Stuff:** music/photos/video

Even this quick analysis exposes how components in a product can be logically grouped by rate of change. Think about how this could be applied to other products—what is the Stuff layer of a microwave or the Services layer of a web site?

Each layer can change at a different rate but its speed is not completely divorced from the others, slower layers tend to constrain the faster ones. Brand describes, "How a room is heated depends on how it relates to the heating and cooling Services, which depend on the energy efficiency of the Skin, which depends on the constraints of the Structure."[33]

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[33] Brand, 17.

Slower layers can provide continuity while the faster ones allow for individuality. Designers need to provide solid foundation layers that can support faster changes on top of them, but they must also take care not to couple the layers too closely. An adaptive product "has to allow slippage between the differently-paced systems . . . Otherwise the slow systems block the flow of the quick ones, and the quick ones tear up the slow ones with their constant change."[34] Layer slippage, achieved through modularity, insures that a product remains cohesive even as it is changing.

Modularity can also help expose a product's seams—visible clues about how the layers are joined and how they can be altered. In a building, seams might allow for easy access to wiring in ceilings or conduits, but what does it mean for products? One way to explicitly expose the seams of a product is through documentation. Home builder John Abrams has made a habit of thoroughly photographing the houses he builds before putting up the walls, so the owners can see where all the plumbing and wiring are. This photographic record helps make "later adjustment of the building so much easier. The photos reveal exactly where the Services go and what are the hidden Structural elements."[35] Imagine similar documentation for a product that shows where the layers are separated, how they fit together, and how they can be changed. A product "needs a complete and accurate record of itself"[36] so that people can avoid reverse engineering by trial and error when they want to make a change. Good documentation and visible seams enable maintenance of a product over a long period of time, and time is perhaps the most important requirement for successful evolution. Alexander acknowledges that adaptation happens slowly, that "you want to be able to

[34] Ibid., 20.
[35] Ibid., 198.
[36] Ibid., 207.

mess around with it and progressively change it to bring it into an adapted state."[37] One can recognize when this is successful because each product begins to take on a "unique character" as it diverges from the others based on individual changes.

Adaptation moves products from conventional to personal because people make changes that are important and personally beneficial to them. These might be prompted because the product is no longer meeting their needs, is mediating their actions in a negative manner, or they want to avoid an undesirable consequence. Regardless, they are making changes based on a particular and unique context. But there are also people for whom the product never met their needs in the first place, who are using it as a starting point towards creating a unique vision. The layers of change approach is a way to plan for and allow adaptation through flexibility, but based on what people hope to achieve the way they adapt products can be significantly different.

When looking at methods of adaptation the two poles of the continuum are "satisficing," a word from decision theory combining "satisfy" and "suffice," and optimization. Satisficing is the most common method and the one that prevails in natural evolution. These "solutions are inelegant, incomplete, impermanent, inexpensive, just barely good enough to work."[38] They are never optimal, even after successive iterations, but they are convenient, simple, and easy to adjust later. "Satisficing doesn't try to solve problems. It reduces them just enough."[39] Conversely, Von Hippel has studied what he calls "lead users," who adapt products to achieve optimal results. He defines a lead user as someone who is "at the leading edge of an

[37] Ibid., 21.
[38] Ibid., 165.
[39] Ibid.

important market trend" and "anticipate relatively high benefits from obtaining a solution to their needs."[40] This definition points to a person who is dissatisfied with a product not because something in their context or situation has changed slightly, what they need is significantly different from what is currently available. Lead users can often be found within marginalized but dedicated activities such as extreme sports. For example, a serious "[mountain] biker may be totally unwilling to compromise about getting mountain biking equipment that is precisely right for his or her specific needs."[41] Because of their focus on optimization Von Hippel dubs lead users "user innovators" and implores designers to pay attention. What can designers learn from looking at lead user innovations? How are the changes they make to a product different from those who satisfice? These two types of adaptation are reminiscent of what organizational learning theorist Chris Argyris calls "single-loop" and "double-loop" changes. Single-loop changes are in reaction to a simple feedback loop. Small, incremental, constant, satisficing changes to a product, "like a thermostat turning the heater on and off."[42] In a double-loop, minor adjustments are not enough and major changes are made, "the thermostat is reset to a different temperature entirely . . . the existing habitat, no matter how perfectly refined, no longer serves the larger purpose." Single-loop changes are made to maintain situational equilibrium using a small amount of known variables, double-loop changes fundamentally alter and re-optimize for a new situation. Lead users adapt products in a double-loop manner that designers will have trouble anticipating since they tend to make new and transformative changes. Unlike most people, lead users make changes to the slower foundational

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[40] Eric Von Hippel, *Democratizing Innovation* (Cambridge: The MIT Press, 2005), 22.
[41] Von Hippel, 34.
[42] Brand, 167.

layers of a product. Normally products start off roughly meeting a person's needs and are only adapted as situations change. Accordingly most adaptation is a made up of single-loop maintenance-like modifications, and these are the changes that designers can best provide for. But lead users and double-loop changes are worth paying attention to because "products lead users develop often form the basis for [future] commercial products."[43] Unique and extreme needs today can point to the future needs of many.

Because they are on the early edge of the adoption curve, lessons learned from watching lead users can feed into scenario planning but designers can also learn from observing single-loop adaptations. Small changes, in the aggregate, can say something important about the default version of a product. Consider that some layers in a product, like Stuff and Space Plan, will be changed rapidly to meet individual user preferences. If a designer observes that a large percentage of people are making similar changes to a product it may indicate that the default design is undesirable. For example, imagine a photo sharing website that by default showed the latest photos you have taken on the homepage, but allowed you to change it to show your friend's photos instead. If designers notice that most people have changed the product in this way they could adjust the default layout so that friend's photos are shown first. Designers can continually work on the "official" version of a product, improving it over time by watching how it is used. In this way the design process does not have to end when a product is released and evolution can happen through collective as well as individual involvement.

Designers can learn a lot from watching people make changes to products but individuals can also learn from each other. "Informal user-to-user cooperation, such as assisting others to innovate, is common. Organized

[43] Von Hippel, 23.

cooperation in which users interact within communities, is also common."[44] Because of the Internet, people with a shared interest, no matter how niche, can easily find each other. Users of a particular product may take it upon themselves to create a community centered on its evolution, an idea seen in its purest form by looking at large open source software projects. In these communities there are hundreds of people directly contributing to the evolution of a product through modifications of software code. The people involved are not paid to improve the product and often, like most adaptation, the changes they make are entirely self-motivated. Over time though these individual changes add up and the product evolves based on collective needs. In reference to this emergent process open source pioneer Eric S. Raymond has commented, "given enough eyeballs, all bugs are shallow."[45] Embedded in that statement is a reference to what Von Hippel calls "sticky information."[46] He defines information as "sticky" when it is held by one person but costly or impossible to transfer to another. Ask a professional skateboarder how they perform a particular trick, or an artist how they came to the form of a sculpture—they will likely have trouble articulating a list of steps. Information about needs that people have can be also "sticky." Consider how it is far too costly for a designer to discover every possible need in a given solution space, and costlier still to design for all those edge cases. But people in a given situation tend to know exactly what they need, especially when something goes wrong. Raymond's observation is what happens when there is a high degree heterogeneous needs and the people affected know how to develop solutions themselves—even niche problems are found and fixed quickly.

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[44] Von Hippel, 93.
[45] Ibid., 94.
[46] Ibid., 66.

Looking outside of software, take for example a mountain biker who discovers that her feet leave the pedals when doing certain mid-air tricks. To even encounter this problem a high level of "sticky" skill must be present, and adapting the pedals to keep her feet attached will require her to use this information in repeated trial and error. "The result is the creation of a low-cost laboratory for testing and comparing different solutions to the problem."[47] Modifying the pedals is easier for this particular mountain biker than it would be for someone unfamiliar to this use of the product, it is also more enjoyable because she is participating in her chosen activity while learning something new and being creative. The enjoyment one gets from improving something they care about should not be overlooked, the process, as well as the outcome, lures people to adapt and evolve products. In this case the need is "sticky," but the way she makes changes to the product will also happen with "in stock" knowledge. The vast majority of people who modify products do so with knowledge they learned from their professional background or through use of the product itself,[48] very rarely will they seek out unknown solution techniques; this makes sense since everyone has particular skills and experience they can bring to a situation. Consider how a professional welder, someone with a hobby doing leatherwork, or an avid snowboarder, might modify the mountain bike pedals differently. Products are adapted using whatever techniques come easiest to the person making the change.

"Sticky" knowledge tends towards individuals discovering and fixing a problem themselves, so why do people contribute to communities? Going back to the open source example, why would people share a bug fix or feature they have added to the software? When people freely reveal changes

[47] Ibid., 75.
[48] Ibid., 74.

they have made they benefit in numerous ways, including increased community reputation, positive networks effects, and because often "others then improve or suggest improvements . . . to mutual benefit."[49] In particular, the way a solution is implemented can be improved upon by others with different and perhaps more applicable solution knowledge. Another reason is that similar to commercial products where designers control the "official" version, every open source project has leaders who decide what is included in the official release. By having their individual modifications included in the collective version it is easier for people to upgrade their software in the future, without going back and making the change again. By being a part of the community people play a part in evolving the product at a higher level, beyond their individual copy.

Outside of the open source world legal restrictions often hamper the creation and growth of user communities focused on product adaptation. Companies use patents to lay claim to a particular innovation or idea, which disallows others from using or building on top of that. To ward off competition "Major firms can invest to develop large portfolios of patents. They can then use these to create 'patent thickets'—dense networks of patent claims that give them plausible grounds for threatening to sue."[50] In the software and media worlds copyright is used for the same purpose, companies control how people can modify products they legally own, justifying these restrictions with laws created to thwart piracy. A tension exists between these sorts of business practices and product evolution because people are being legally hampered from adapting products. The patent/copyright business model has worked well in the past, and at times today there is evidence that it drives innovation and healthy competition. It

[49] Ibid., 10.
[50] Ibid., 12.

is not however the only way, and is marred by how it places control of a product solely in the hands of a single company. Some businesses stand to benefit from a more open and democratic model that allow for, and even encourage individual people's involvement. One advantage of this alternative approach is that by watching how people adapt products to new uses companies can gain valuable information about customer needs and potential new markets. This "sticky" information is traditionally very costly to obtain, but is free when they nurture or listen to a product adaptation community. "As information about what users want and need to do becomes more fine-grained, more individually differentiated, and harder to communicate, the incentives grow to shift the locus of innovation closer to them by empowering them,"[51] in addition, an open model that legally allows people to modify products can attract new customers. As detailed previously, having the freedom to change a product as needed provides numerous personal benefits and in turn can confer goodwill on the company. Finally, businesses may be forced to adopt an open model to survive. The advent of easy to use software tools and rapid prototyping equipment points towards a decreasing "stickiness" of solution information. If a company is too restrictive concerning how people use and adapt their products this may spur their would-be users to become competitors. Consider that the open source community actively strives to provide functional alternatives to commercial products, without the legal restrictions on modification. Moving toward a more open model that encourages user involvement may be the only way to retain customers who are tempted by free and flexible alternatives. Products that cannot evolve are increasingly viewed in a negative light. This is influenced by the contemporary nature of products and society where change is the norm, customization is expected, and the intertwining of products and

[51] Ibid., 170.

services creates a focus on the overall experience. Products should be able to evolve through use, allowing people to adapt them to changing needs, shifting contexts, and unforeseen uses. The demand for adaptable products has an ethical dimension as well, because they do more than fulfill a function. Products mediate our interactions, influence our behavior and change how we perceive the world. People deserve the autonomy to avoid undesirable consequences and influences and create new and positive ones.

## Conclusion

The role of technology in our lives increases rapidly every year, mediating not only our individual actions but effecting how we interact and communicate with one another. The technological saturation of our lives can have both positive and negative effects, making new things possible but causing unanticipated problems as well. For products to be empowering rather than controlling they must give people the freedom to adapt them as they see fit and flexibly account for the many situations and systems that they must integrate into. One cannot design a custom product for each person, but a mix of resources, capabilities, and time can help a product integrate into someone's life in a way they choose. Designers must look beyond creating products that are useful and usable for today and consider how these qualities can be maintained in the long view. For this to happen designers need to involve people in product creation and evolution—giving them a greater role than just having needs to fill; this calls for a change in the role of the designer, the process, and the outcome of design. Traditionally a designer crafts the form of a product based on set functionality, inscribing it with a particular program of action and delegating it a specific task. Although they will continue to create the initial form of a product it must now be done in a more humble manner. The form should be based on the numerous ways

people can interact with and adapt a product, providing tools such as modular layers of change and rules to maintain a cohesive whole even as those layers evolve independently. As a compliment to user-centered design a strategy for change must be developed, and a longer-term engagement after a product's release will allow designers to evolve the "official" version based on individual and collective adaptations. The process diagrams on every design firm's website may need to change, but the role of the designer will be no less important in a world of evolving products. The process will still start with research and designers will still do the initial planning to build a solid foundation of system components. Designers will still craft the form and release a product, only the designing will no longer end there. By providing the resources and opportunities for people to be involved in product evolution designers extend their role and the life of what they create. The role of designers needs to change from inscribing a particular use to facilitating many, from acting as delegators to being enablers.

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