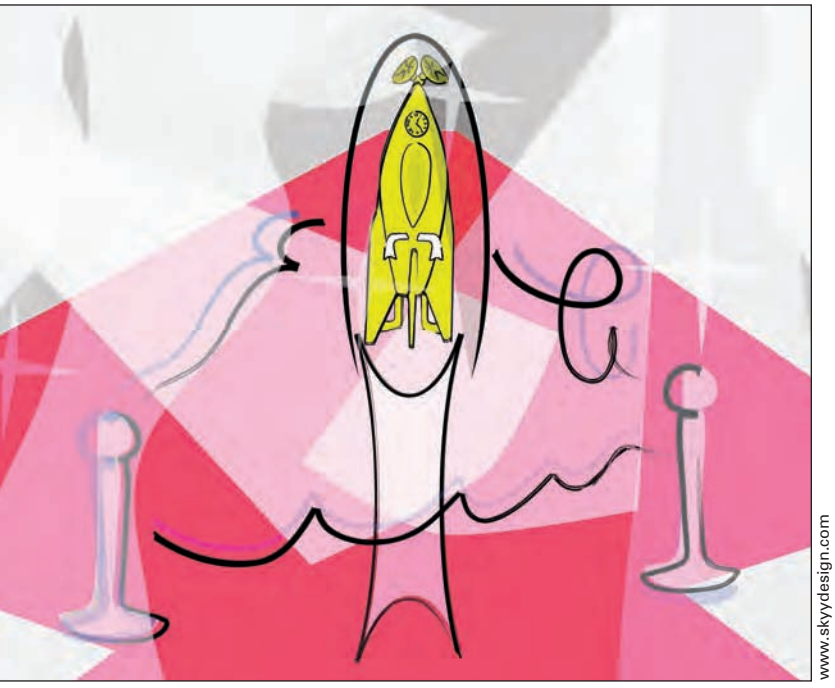
# Prototyping: Generating Ideas or Cargo Cult Designs?



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**IN INTERACTION DESIGN,** it is common to use mock-ups, prototypes and other representations to explore an interactive system before it is actually built. This can range from simple cardboard cutouts to elaborate graphical simulations (see Sidebar 1). This approach has been particularly fruitful in participatory design, where users are brought in very early in the design phase. A representation can be a vehicle for communication, a tangible "placeholder" for the real thing, which represents a proposed artifact's role in a real-world situation. Designers and users can thus explore the user experience of a system together, before it actually exists—even if it is only represented by an empty cardboard box.

But there is a danger with putting too much faith in what is, after all, only a shadow of the real thing. Prototypes and mock-ups are only pointers to what may be and as such, they must be treated with respect. If a designer or researcher presents such a representation as an end product, an uninitiated audience or customer may easily be fooled to believe it is the real thing.

What is the difference between the positive and negative uses of representations? Inspired by a metaphor of the "cargo cult", we will point out some potential problems in relying on prototypes and mock-ups. We discuss how such representations can embody and create knowledge. Finally we will see that there are alternative, fruitful ways of using representations, deceptively similar to the "cargo cult", which we call "generators".

***The Cargo Cult Metaphor.*** The concept of cargo cults has been a source of fascination for many years and has often been used as a metaphor. The most widespread account was given in the "shockumentary" film *Mondo Cane* [9]. Although the filmmakers were known to stage certain events for dramatic effect, the section on cargo cults seems substantially correct, and it can be traced to virtually all subsequent uses of the concept.

At the beginning of the 20th century, as a result of

*They believe that planes come from paradise—their ancestors sent them. But the white man, a crafty pirate, manages to get his hands on them by attracting them into a big trap of an airport. You build your plane too, and wait with faith. Sooner of later, your ancestors will discover the white man's trap and will guide the planes on your landing strip. Then you will be rich and happy.*

*—Narration from the film* **Mondo Cane,** *1962*

an influx of Western technology, a certain form of religious movements started to spring up in the Melanesian islands in the South Pacific [10]. These religions thought that the goods—the *cargo*—that started to arrive on ships and planes had a divine origin, or more specifically that it came from their ancestors. The Melanesians developed rituals to ensure that the riches arriving on the planes were not stolen by the white man and started to imitate the behavior that seemed so successful in attracting cargo. They even built imitation airplanes, control towers and landing strips in the hope that cargo planes would come. The Melanesians reasoned that if they could build exact replicas of the white man's artifacts, they would receive the same benefits. What they failed to realize was of course that their replicas, made from bamboo and straw, while superficially similar to the real thing did not capture the essence of the original artifacts.

The performing of imitative rituals without an understanding of the underlying cause and effect is what gives the cargo cult its metaphorical power [12]. The most well known example is by physicist Richard Feynman, who coined the term *cargo cult science* in a Caltech commencement address in 1974 [6]. Feynman used the term to describe a certain type of scientific dishonesty—fooling other scientists or the general public by presenting research results as "fact" even though they are not proven correctly. A typical example is "pseudo-science" (e.g. mind reading), but could also be a scientific experiment where the researcher fails to include previous work that invalidates the outcome. This would mean that the results at hand have little or no value even though they appear superficially correct. Feynman stressed the importance of "a principle of scientific thought that corresponds to a kind of utter honesty." He advised scientists to follow two principles that can also be applied to interaction design: do not fool yourself; and do not fool the layman.

***The Story of the Intelligent Mobile Phone.*** How does cargo cult behavior appear in interaction design? The following is an illustrative story based on a real experience about which the details have been changed.

I once met a representative of the research arm of a major telecommunications company who talked about his latest project, the "intelligent mobile phone." This remarkable device would detect the state of the user automatically, and adjust its behavior accordingly. For instance, if the user was in a meeting, the phone would not ring, or would ring at a lower volume appropriate to the situation. It could detect many other situations equally well and would adjust its behavior accordingly. The researcher explained that this intelligent mobile phone was currently being displayed for the first time at a commercial technology exhibition.

Having worked in the field of context aware applications, I knew that making such a phone requires solving many very complex problems. I was impressed that this company had apparently solved some of them well enough to present the results at a major exhibition. I started asking for details about the phone, making references to other projects that had attempted to make similar devices but had not even come close to a working implementation.

However, it became apparent that the telecommunications researchers had not heard of any of these related projects, or of any other research in context awareness for that matter. When asked how the company had implemented the functionality of their "intelligent" mobile phone, the researcher answered: "We have not actually implemented anything yet. Right now, we are just showing a mock-up."

***Cargo Cult Design.*** What the researcher in the story did was to present an artifact that *looked* like an intelligent mobile phone, giving the exhibition visitors the impression that it was the real thing. This is sur-

### Representations, Mock-Ups, and Prototypes

Designers in all disciplines make use of sketches and models to envision artifacts before they are actually constructed. Interaction designers, specifically, often use mock-ups and prototypes as a natural part of their work process [2]. Such "incomplete" representations can be used to explore potential avenues of design, to present a concept to a client, to demonstrate a proposed interaction technique, to perform a preliminary user study, and so on. A mixture of prototypes and mock-ups will often be used for different stages in a design process to represent certain aspects of an interactive system [1]. In this sense, representations in interaction design rest on a foundation of practice developed in fields such as product design and graphic design. However, the terminology is not always clear, and some even argue that in interaction design, *all* early representations are a form of prototype [1]. Here we prefer to keep mock-ups and prototypes distinct, using the term *representation* to refer to them collectively.

*Mock-ups* are objects that have the appearance but not the function of a certain artifact. They have a long history in traditional design, and more recently in interactive systems design. By constructing a simple representation from readily available materials, the designer can often identify potential problems and explore alternative avenues early in the process, without investing the work involved in creating a fully functional artifact. For an industrial or product designer, this is a natural way of working, since the functionality of the object is usually already specified or known to be confined within certain parameters. In fact, sometimes the mock-up has qualities that are so close to the finished article that certain aspects can be tested for real; for instance, a chair might be produced in a material strong enough to sit in once or twice but not suitable for eventual production.

*Prototypes*, on the other hand, can be defined as having the functionality but not the appearance of a finished artifact. Constructing prototypes are a common activity in engineering and computer science, where they can be used for proving or disproving a certain theory. If a researcher believes that technology can be used to solve a problem, the best way of proving it is by constructing a functional prototype. This prototype will most often not have any of the appearance or properties of the envisioned product-for instance, it might be larger and heavier, or might have a much shorter operating time, or only partially implement the desired functionality. But by its very existence, the prototype constitutes an existence proof that a technology works.

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prisingly close to the rituals of the Melanesian natives! We can define cargo cult design as *creating a representation without sufficient knowledge of how it actually would work, or presenting the representation while not acknowledging such knowledge*. In other words, in an analogue to Feynman's cargo cult science, pretending that the apparent functionality of an artifact is real and based in fact, when it actually is not. It is possible that for the person in the intelligent phone story, it seemed reasonable that the technical problems of creating such a device should be fairly easy to solve. But no matter whether he made any attempt to verify this assumption (with the risk of being proven wrong), or if he knowingly made the exhibition visitors believe that the phone was functional, the use of the representation in this case was obviously deceptive.

Non-functional representations are often used to explore potential avenues for design in more or less realistic situations. If this is done as a sort of play-acting, and all concerned are aware that the representation is not real, this can be a useful exercise. In this type of design process representations are used as a "prop" for designers to explore potential interactive systems, sometimes involving the intended users. The participants in such an exercise are either designers themselves, or people who have sufficient insight into the process to not mistake the representation for the real thing. This is a legitimate way of using representations, and one that has recently been gaining a lot of interest in the interaction design research community [1, 2, 8].

But when an artifact has a surface appearance that closely resembles that of a finished product, it is easy to start treating it as if it was just that, especially if the audience does not have insight into the development process or the particular problems involved. Newspapers and magazines are full of stories of concept designs that are described as if they were real

products, especially around the time of final-year exhibitions of design schools. The skilled observer can probably tell which concepts are realistic and which ones are basically a form of wishful thinking [4] but because of the way they are presented, most of us are likely to be fooled by these seemingly functional representations. This is cargo cult design.

***What Do Representations Represent?*** In a design process, representations are a physical embodiment of something that otherwise would only exist as an abstraction. Without getting deep into the epistemological definition, we can say they are the embodiment of *knowledge*. But mock-ups and prototypes represent knowledge in different ways.

A prototype represents the knowledge of *function*; it is a tangible artifact in which the necessary technology to achieve a particular functionality is implemented. However, the prototype says next to nothing about whether it will result in a successful product or systems. This is fine, the developer might argue, because these properties are separate from the function-they are part of the *interface*-and can be optimized now that the fundamental technical problem has been solved. A mock-up, on the other hand, is the embodiment of *form*; this is how an artifact could manifest itself in the world, as a tangible device or as buttons and widgets on a screen. For a product designer, finding the form the artifact will take is the primary problem to solve. Implementing the required functionality, the designer might say, is the responsibility of an engineer.

The interaction designer lives between both these worlds-creating artifacts that merge form and function. Interaction design ultimately relies on algorithms, which govern not just the appearance but also the behavior of an object (see Sidebar 2). Thus, a representation of an interactive artifact will contain properties of both prototypes and mock-ups. Furthermore, the power of a representation is that, unlike an abstraction, it can be put into situations that approach those of real use. Simply put, the interaction designer can take the representation and click on the buttons, weigh it in his hand, or listen to it, getting a feeling for how it might behave in the real world. Even better, he or she can show it to others who have no knowledge of the underlying abstractions. The representation can be discussed, user tested, dropped from heights and carried in a pocket-almost like the real thing!

However, to give any kind of reliable information, the representation must give a *realistic* impression of the intended end product. If the representation is based on insufficient knowledge of real-world factors, presenting it to potential customers or testing it with prospective users will not make much sense. As shown in the anecdote, creating a convincing mock-up is deceptively easy, and therefore a high degree of responsibility is required in its presentations and use. To quote from the influential UTOPIA project: "While [a mock-up] allows a design group to experiment without the limitations of current technology, this freedom is only a partial blessing. In the end, good design results from exploiting the technological possibilities and limitations creatively, not from ignoring them. Thus, as paradoxical as it may sound, the demand for computer knowledge in a design group using mock-ups is very high" [5].

***Representations as Generators.*** When is a representation useful, and when are we in danger of cargo cult design? A view that dominates the engineering disciplines, and is also prevailing in human-computer interaction, is that the more background knowledge a designer or developer takes into account to construct a prototype or mock-up, the better it will be. In other words, by doing plenty of prior research (and ensuring it is taken in account when constructing the representation), the results that come out of using it in

a design process should be more reliable.

This notion seems intuitive. Researchers do their homework carefully, by exploring related work, performing rigid experiments, and so on. The researcher who ignores such activities will be doing what Feynman calls cargo cult science. Similarly, the product developers at major companies do market research, consult focus groups, and look at previous successes. This is necessary to make sure that not a lot of effort and money is sunk into a product concept that is likely to fail. If we apply this to interaction design, the designer should make sure to know as much as possible about relevant technology, cognitive science, ergonomics, user experience and so on before designing a representation.

However, there is an alternative view. Even a fairly simple representation might prove very useful if it turns out to create new insights. A mock-up that represents a system that is technically impossible to realize could still give rise to interesting design ideas and concepts. It might lead the imagination down new paths and free a designer from preconceptions. This may seem very similar to the cargo cult, and in fact the representations used may even be identical. The difference lies in how the representation is used and presented to an outside audience, and in how the outcome is evaluated. To avoid cargo cult design a representation should be presented honestly as what it is—a vehicle for exploration, not an end product.

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In this case the representation is a *generator*. A generator is at the center of a process that generates inspiration and ideas-it is not an end in itself. By making abstract thoughts concrete, and by providing a focus for exploration and discussion, a generator can give rise to new insights. What one should take away from a generator are ideas and inspiration, which are *potentially* valuable. However, the designer should be aware that this potential knowledge must be judged, validated and refined before being used or disseminated. Therefore, the value of representations as generators lies in how much the designer can ultimately take away from them, not the rigidity of the knowledge that went into creating them.

***Generators in Interaction Design.*** The generator concept is not really new—in fact it illustrates an approach common among artists and designers. For these disciplines it does not necessarily matter what goes into a design, but how good the result is. Creative designers fetch their inspiration from a multitude of sources, some of which may seem completely irrelevant for the end product. Furthermore, they are also skilled in quickly creating representations and using them for explorative purposes. For instance, graphic designers often generate a great number of mock-ups from which desired qualities are chosen to go into a final design [3].

Interaction designers can use mock-ups in a similar way, to explore avenues of design before starting actual implementation. These representations function as generators, but the results they produce for instance when evaluated with potential users must be weighed carefully. The mock-up can be a useful focal point for discussion, to generate inspiration and ideas, to open a window to new possibilities—as long as everyone involved is aware of its limitations. If the intelligent phone in the story had been presented in this way, it could have been used as a starting point for exploring

important issues. Do we really want this kind of device? What we would like it to do if we had one? Is it possible to construct it? What should it look like, how much would it cost, and so on.

Technology itself is also an important generator. Many of the innovations in interactive systems stem from prototypes created for explorative purposes. When the desktop computer was created at Xerox PARC in the 70s it was as a collection of newly available technologies rather than as a tool with any particular purpose. When the foundations were laid, researchers found many valid uses for the technology. But these applications were often developed as a response to new technical possibilities, rather than to support a particular task. And in fact, the personal computer would not constitute a valid commercial market until more than a decade later, when Apple took over many of the same ideas.

Generators can also be provocative. Dunne engaged in a form of critical design, by creating "value fictions"—technically plausible design proposals that challenge conventional values [4]. These proposals may seem like cargo cult designs, but are not presented or intended as potential products. Instead they are explicitly created to stimulate thought and debate through exhibition and dissemination. A similar approach can be used to generate unusual and innovative design ideas, by creating representations that embrace seemingly irrational ideas [7]. This does not mean that the end product has to be irrational; speculative designs can ultimately lead to viable proposals for real products [Martin & Gaver 2000]. Thus, representations like mock-ups and prototypes can be used as generators in interaction design, much like other design disciplines bring in a variety of influences to create a variety of sketches and proposals as input into a design process.

In the design of interactive systems, representations must be used responsibly. No matter how enticing

### Representing Algorithmically-Based Artifacts

Representations can be problematic in all design disciplines, but this is particularly relevant for interaction design, where function and form are intrinsically linked. When an object relies on purely mechanical operation, the function is closely related to the form and it will be fairly easy to determine if it has a chance of working as a real product. Humans have a good understanding of the physical world, and we can identify obvious impossibilities—we can see and feel if an elegant chair is too flimsy to support anyone's weight, or if a great-looking bag is too small to actually hold anything of value.

Artifacts in interaction design, on the other hand, rely ultimately on the execution of computer programs—in other words, algorithms. The intuitive understanding of what algorithms can and cannot do is still poorly developed, at least for people outside computer science. There are many seemingly simple problems that are hard or even impossible to solve with algorithms. For instance, the classic "traveling salesman" problem cannot be fully resolved in a reasonable time with any existing computer. Yet such problems may *seem* tractable, because we are so used to the accelerating pace of technical progress that we naturally assume that a faster, smaller and cheaper computer will come along to solve them. The intelligent mobile phone is an obvious example. It may sound reasonable that such a device can be constructed, but researchers in context aware computing know that it is simply not possible with current technology.

This reliance on algorithms is one reason that a mock-up of a computer-based artifact may be much farther from the "real" object than a chair made out of painted cardboard. Developing and testing prototypes is a way to get closer to solving such problems. But prototypes can also give the wrong impression, because while they may well work on a technical plane, the proposed artifact may be completely useless when considered from a social, commercial, or user-experience perspective. The crux is not the type of representations that are used—it does not matter if they are empty cardboard boxes or fully functioning circuit boards. Instead interaction designers must be aware of the fundamental issues in algorithmically based artifacts, and that not everything can be solved simply by introducing a faster, smaller computer.

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a design is on the mock-up stage, it is of virtually no value—except as a thought experiment—unless the interaction is also possible to implement. While it is easy to assume that everything relating to interaction technology will become possible because computers are becoming ever faster and smaller, the reality is that many problems are still impossible to solve. On the other hand, even if an interactive artifact is fully implemented at the prototype stage, this might not mean that it will make a compelling end product. The artifact may be based on fundamentally incorrect assumptions about how people interact with technology or each other, and in such cases no matter of successful lab testing or technical validation will be enough to make it relevant for users. Mock-ups can be used to explore such issues even before a system is implemented, and is thus an important complement to prototypes.

Cargo cult design and generators represent two sides of the same coin. The difference between them lies in their presentation and use, rather than in their content and how they are created. Feynman's two principles for honesty in science can be used to identify potential cargo cult designs [6]. When presenting a mock-up or prototype, the interaction designer should always ask:

1. Am I fooling myself? Do I really have enough knowledge of the technology and the users to gain valuable insight from this representation, and will it help me to construct the "real thing"?
2. Am I fooling the layman? Is there a risk that people mistake the representation for the real thing, and thus believe that I have solved problems that I have not?

But the interaction designer should also see the value in representations as generators. Even when the knowledge that goes into a representation seems questionable or even irrelevant, it can still be valuable, as long as the results are treated responsibly. There is value in toying with and the possibilities of technology and being inspired by them; prototypes that may not seem useful can give rise to many unexpected ideas and eventually form the basis of successful products. With the concept of generators comes an explorative attitude to the development of interactive artifacts. Interaction designers should be encouraged to take representations, prototypes and mock-ups of all kinds as starting points for exploration—but never accept them at face value.

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