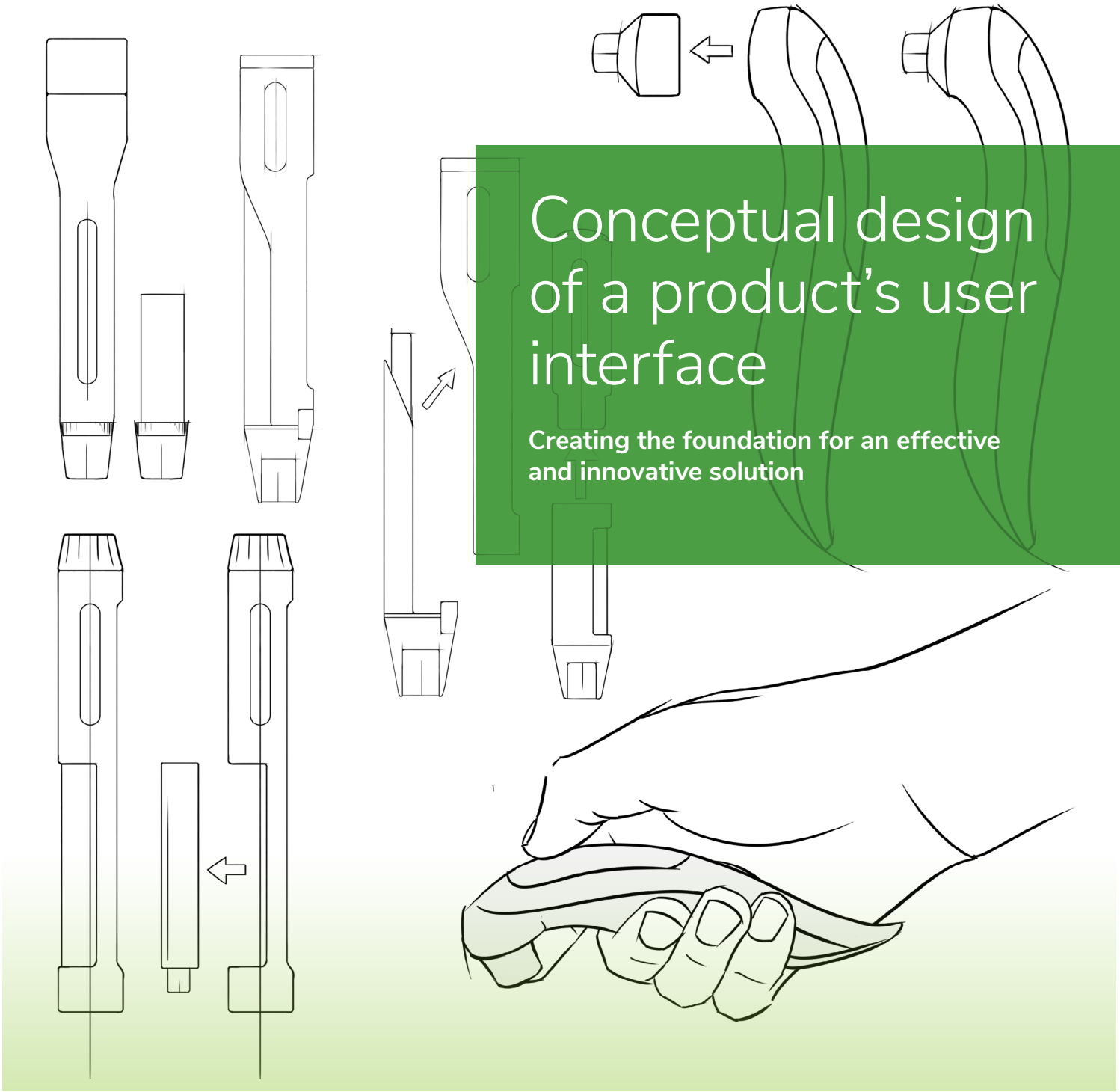

Conceptual design of a product's user interface

Creating the foundation for an effective and innovative solution

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Executive Summary

Among all of the user interface design process stages, conceptual design is most often overlooked or rushed. In principle, this stage starts with a clean sheet of paper and lots of blue sky thinking. This does happen in some cases. But in many other cases, product development teams prematurely converge on a user interface that resembles its predecessor or even that of a competing product. Carrying forward the characteristics of a pre-existing user interface might serve the goal of positive transfer — making a new design familiar — but it might also indicate failure to conceive of a better solution that meets evolving user needs. Rushing through conceptual design can also cause you to miss the opportunity to validate your assumptions and discover unmet user needs.

A comprehensive conceptual design effort is likely to place your user interface design process on the right path and avoid ill-advised shortcuts. In addition, it will help ensure that the final product is safe, effective, and satisfying to use.

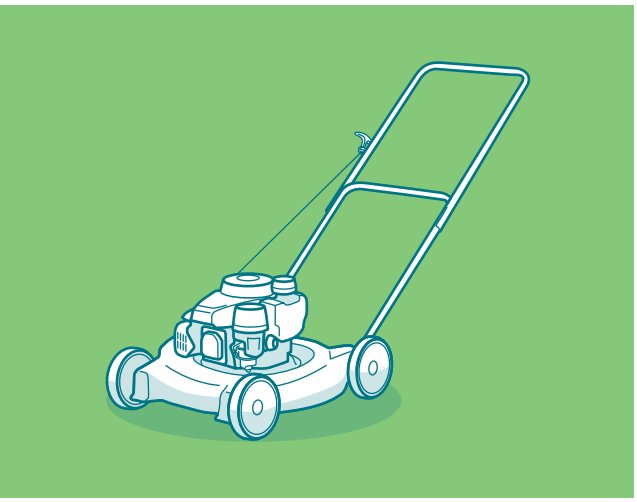
There is no one best prescription for conceptual design. Ask a dozen user interface designers about the purpose, process, and outcome of a conceptual design effort and you are likely to hear widely varying explanations. Such variability is not necessarily a bad thing. After all, conceptualizing a solution to a problem is a creative act that is inherently unique to the individual or team engaged in the activity. That said, even with variation in approaches, comprehensive conceptual design efforts tend to include five common steps, which are described below.

Conceptual Design Process

1. Collect and review research findings

Conducting research on users' product needs and preferences is a smart preamble to conceptual design. It prevents the classic blunder of designing a product based on assumptions about users' needs and preferences. Such a blunder is likely to lead to a product that misses the mark by not having a desired feature, taking too much time to operate, being uncomfortable to hold, looking weird according to users' taste, or possessing other problematic deficits or barriers to use. You can avoid poor outcomes by discovering these and other problems through user research.

Common user research methods involve observing people engaged in pertinent activity and asking them about their product needs and preferences. Such methods may be called market research, field research, ethnographic research, and contextual inquiry.

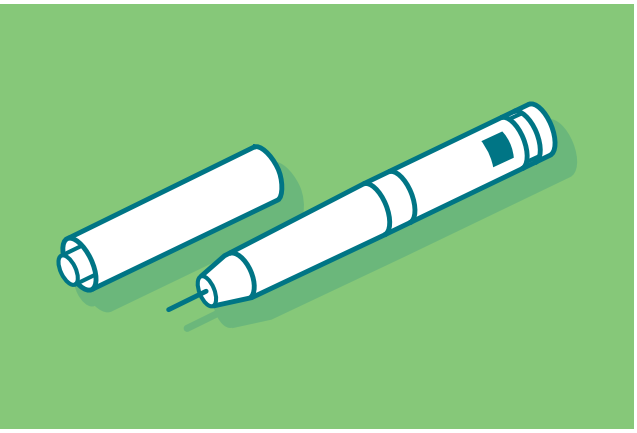


Observations uncover unmet needs

If you were designing a lawn mower, you might observe users and collect their needs and preferences to guide your conceptual design effort, learning the following:

- "I'm very tall and my partner is very short, so an adjustable handle would be nice to have."
- "I always spill fuel when filling the tank, so maybe there is a way to prevent spills."
- "Why can't checking the oil be easier, like simply reading a gauge?"
- "I have to mow and then de-thatch when it would be nice to do it all at once!"
- "I have run out of gas several times, so a gas gauge would be great."

Note that these needs and preferences might spark innovations that could be market differentiators.



User research can be generative

If you were developing a medical device, such as an insulin injection pen, energetic user research might include working with users to generate insights that spark innovation or at minimum confirm your assumptions about user needs and preferences. Here is a sample of possible findings:

- The cap could somehow remain attached to the pen to avoid loss.
- The pen injector could indicate the dose: "20 units delivered."
- The device could beep when it is time to remove it from the skin.
- It could be easier to hold the pen when injecting the back of one's arm.
- The pen could boldly display when it has passed its expiration date.

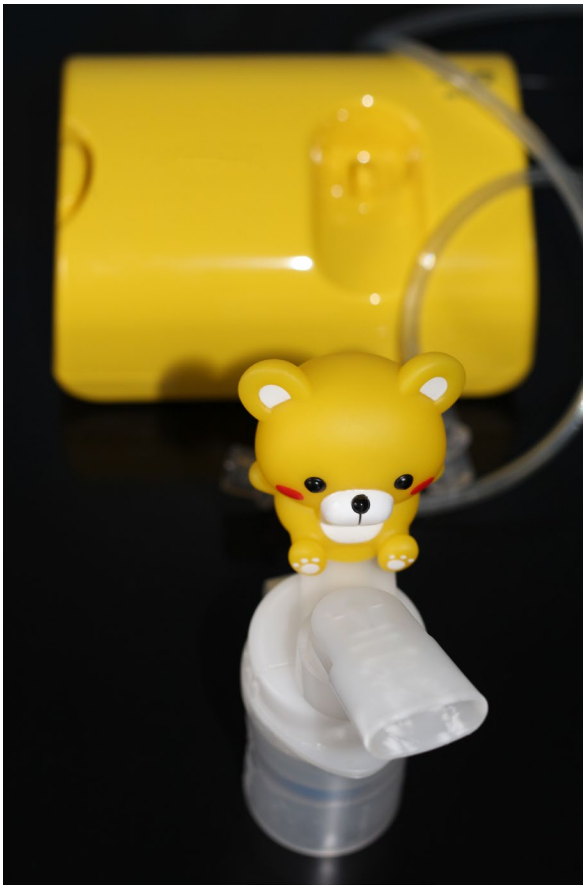
2. Benchmark comparable products

The expression “imitation is the sincerest form of flattery” only partly applies in the product design world, particularly in view of patents and other forms of intellectual property. Also, most new product development efforts aim to improve existing products rather than produce a “me too” product. Nonetheless, before proceeding in a new and (aspirationally) improved direction, it is helpful to examine the competition through an activity called benchmarking.

Benchmarking gives you greater context for your product

Suppose you are developing a new nebulizer for children. You could isolate yourself and work with a clean sheet of paper, so to speak. But you would benefit from studying existing designs such as the one shown below.

In doing so, you would get a better sense of the design landscape and trends. The sample product shown below tells a story of designing children’s nebulizers to be toy-like and non-intimidating while getting the job done. A thorough benchmarking effort will provide many more insights that form the foundation for informed and creative exploration. Importantly, it reveals population conventions — user interactions that are performed the same way across like products — and opportunities for innovation and differentiation.



Attributes to consider when benchmarking

For the typical medical device, combination product, or *in vitro* diagnostic device, benchmarking with the intent to inform a user interface design can focus on these and possibly many more features and characteristics:

- Color use
- Controls
- Displays
- Durability
- Ease of learning
- Ease of use
- Efficiency of use
- Feedback
- Finishes
- Footprint
- Form
- Instructions
- Material
- Operational steps
- Packaging
- Parts
- Play value
- Safety features
- Setup (assembly)
- Shape
- Size
- Sounds (audio)
- Style
- Visual appeal

What constitutes a user interface design concept?

A user interface design concept can be a sketch on the back of a napkin or something more elaborate, such as a 3D rendering of an object or several software screens linked together like a PowerPoint presentation on steroids. The point is to delineate an idea in a form that effectively communicates to the target audience, which often consists of development teammates and possibly a sample of intended users (i.e., customers).

A hardware concept will usually reveal the product's overall scale, general form, and major external features. The product's user interface might be suggested by such features as a computer display and major controls (e.g., button, knobs, levers), each rendered in a general rather than specific manner.

A software user interface concept will usually take the form of a series of screens (electronic or hand-drawn) that include basic onscreen elements (e.g., headers, data entry fields, scrollable content, touch targets). The screens will act like panels in a cartoon to give a sense of action (i.e., interaction).

3. Develop a vision (i.e., high-level specifications)

From your user research and benchmarking, you will have a growing sense for the market opportunity and what kind of product is needed and likely to be successful. Now you are ready to develop a vision for the product. A good place to start is with a vision statement, which will be several sentences, and perhaps even paragraphs, that describe the opportunity and the most fundamental characteristics of a well-matched product. The statement should speak in generalities and eschew specifics that dictate a particular solution. This statement serves as a guiding beacon that keeps the ensuing concept going in the right direction. The vision statement will point the design effort in the correct cardinal direction such as west, rather than specifying an exact bearing, such as 250°. You might consider this a "persona" for your product.

Excerpt from a vision statement for a hypothetical product

The oxygen concentrator shall be optimized for older people who may have weakness and other frailties. Therefore, the device will be exceptionally compact and lightweight. It will be simple for users to independently place the device on their bodies and reach all controls and manipulated features. The controls will be optimized for use by individuals who might only have the use of one hand and those who have limited hand dexterity, sensation, and strength. User interactions with the device are limited to... (continues)

As you can see, a vision statement serves as a broad-based design specification — albeit with a strong focus on the user interface — that guides the design until a detailed specification effort is performed.

You can complement the vision statement with a high-level set of user needs and user interface design requirements. However, the vision statement might provide enough of a framework to enable concept generation to proceed.

Sparking innovative thinking

Is innovative thinking a natural gift that some people have and others lack? Yes and no. Yes, some people seem to have the gift. These are the people who are admired for being creatives, "out-the-box" thinkers with a wellspring of fresh ideas. But there is a parallel here to people who are lucky. As the ancient expression goes, "Luck is what happens when preparation meets opportunity."[1] Similarly, creatives bring to bear a wealth of knowledge, experience, and practice at thinking creatively. Therefore, they seem to have a natural ability that is mostly the result of preparation. That said, some people may have an extra-special creative ability that they can use to great advantage.

However, almost everyone has it in them to think creatively and contribute to a conceptual design effort. The contributions take the form of clarifying questions when a team discusses opportunities to innovate. For example, when developing a wearable product, the following questions might lead the team toward generating breakthrough ideas.

- How can we make the product lighter?
- How can we spread the weight across a larger area of the body?
- Would it be better to separate it into two or more pieces?
- Can we get rid of certain features?
- Should we make a child's and adult's version of the product?

Taking a structured approach to idea generation also helps. There is a wealth of approaches described online and in textbooks. Some common elements include good preparation (as stated above and reflected in this paper's content about conducting research), spending time explicitly focused on thinking innovative thoughts, and working with others in a "1 + 1 = 3" manner.

1. Ascribed to Lucius Annaeus Seneca (c. 4 BC – A.D. 65)

4. Generate concepts

With user research and benchmarking results in hand, complemented by a vision statement (and possibility a high-level user interface specification), you can proceed to generate numerous concepts. At this point, you may also have a set of high-level product requirements that can inform concept generation.

Applying design thinking to concept generation

The goal at the conceptual design stage is to generate lots of concepts without obsessive concern for detailed engineering, design challenges, and overall practicality. As a result, you can expect a wide spectrum of concepts that vary from promising to those you will readily dismiss. The tenets of conceptual design include the following:

- Be creative
- Don't prejudge ideas
- Challenge assumptions
- Take the users' perspective

Approaching design in this manner is sometimes called user-centered design. It also exemplifies what is popularly termed **design thinking**.

"Design thinking is a non-linear, iterative process which seeks to understand users, challenge assumptions, redefine problems, and create innovative solutions to prototype and test." - Interaction Design Foundation

Design teams use design thinking to tackle ill-defined or unknown problems (otherwise known as wicked problems) because the process reframes these problems in human-centric ways, allowing designers to focus on what is most important for users. Design thinking offers us a means to think outside the box and dig deeper into problem solving. It helps designers carry out the right kind of research, create prototypes, and test out products and services to uncover new ways to meet users' needs.

The value of perspectives in concept generation

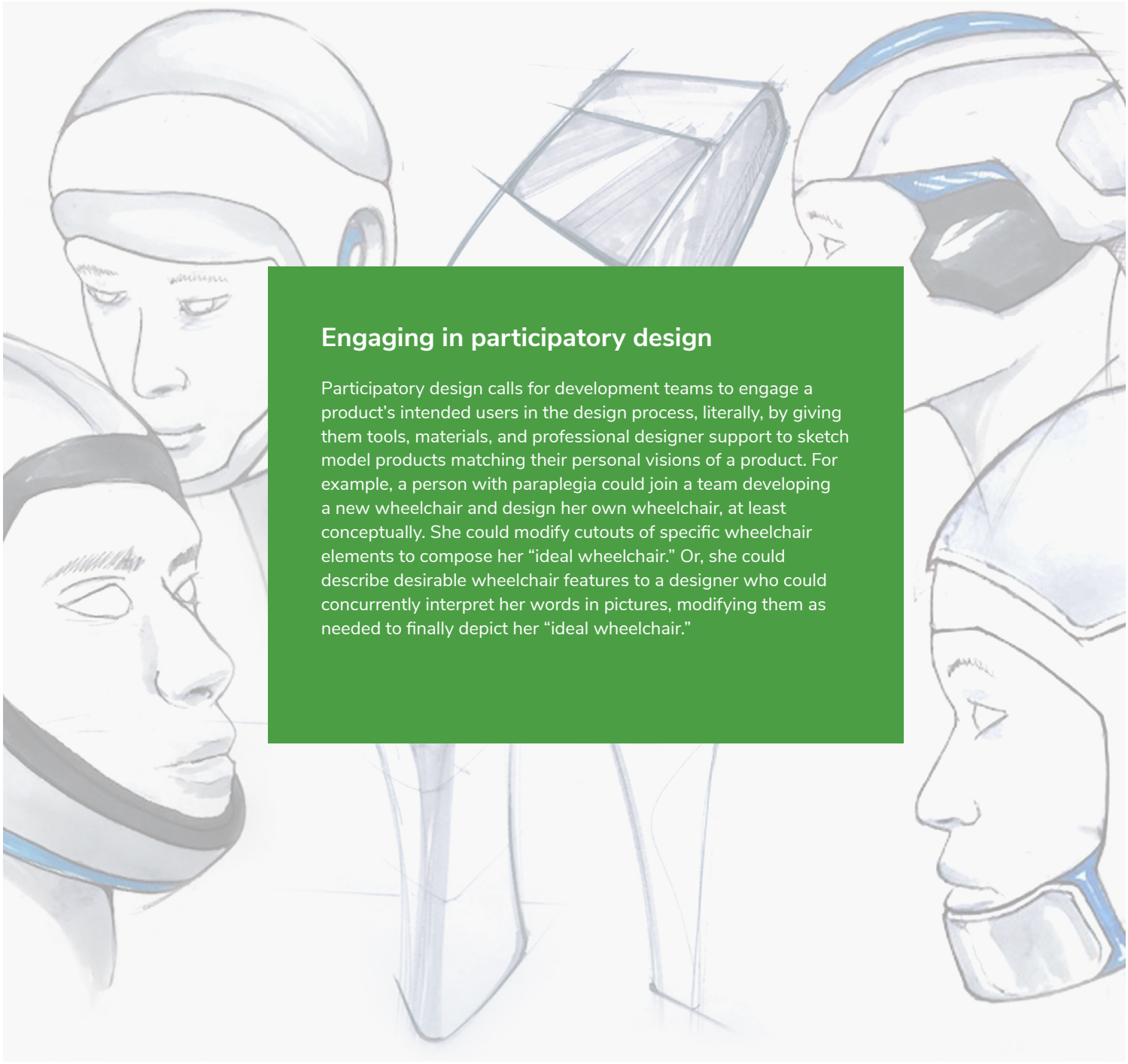
Concept generation can be an individual designer or group exercise. The most likely participants in a user interface conceptual design effort are user interface designers (i.e., people who might have studied human factors, industrial design, or visual design, and are practiced at the art and science of user interface design). However, there is value in inviting people from many disciplines to contribute to conceptual design efforts. This could include people that have spent their time in similar product categories observing users in the field, conducting usability test sessions, managing risk and regulatory requirements, and developing marketing and branding can bring a perspective that is different, and incredibly valuable. Lest we forget, representative users can also participate in concept generation. Designers typically lead "design" efforts, but engaging diverse perspectives in this process will help ensure you generate promising, innovative concepts.

Formats and outputs of concept generation

Design concepts can take the form of hand-drawn sketches such as the ones above. Sketches work well for software and hardware user interfaces. Sketches can also be electronic and resemble real products, thanks to sophisticated software applications such as Figma, Proto. IO, Invision, Solidworks, and Adobe Animate.

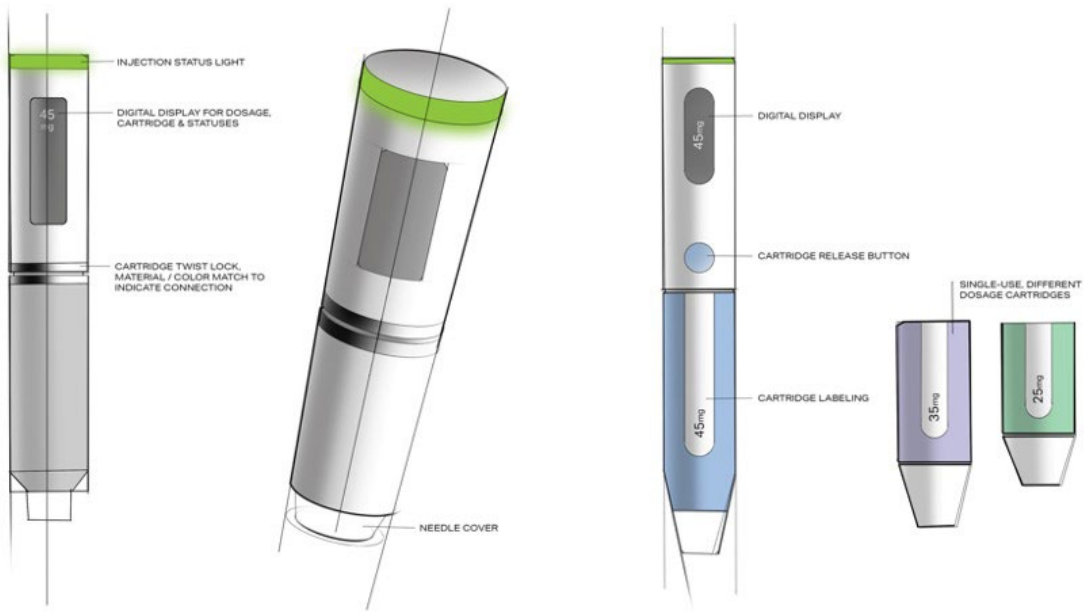
What is the duration of the concept generation step?

Concept generation can span hours, days, or weeks. The starting point is usually putting pencil to paper – or electronic pencil to computer tablet. The ending point is not always as distinct, depending on how many people are involved and how they approach the conceptual design task. That said, there is usually a date when the participant(s) intend to judge the concepts and down-select from many to a few promising ones based on established assessment criteria, described next in step 5.



Engaging in participatory design

Participatory design calls for development teams to engage a product's intended users in the design process, literally, by giving them tools, materials, and professional designer support to sketch model products matching their personal visions of a product. For example, a person with paraplegia could join a team developing a new wheelchair and design her own wheelchair, at least conceptually. She could modify cutouts of specific wheelchair elements to compose her "ideal wheelchair." Or, she could describe desirable wheelchair features to a designer who could concurrently interpret her words in pictures, modifying them as needed to finally depict her "ideal wheelchair."



5. Assess concepts

Narrowing (or down-selecting) concepts, for example from a list of 15 to five, can be done by informed judgment (i.e., intuition, gut feel). But development teams and senior management are more likely to see a more structured down-selection process unfold, which means getting the right people involved and establishing assessment criteria.

Assembling a team to assess design concepts

Who are the right people to participate in the concept assessment process? Ideally you want to include representatives of every group you consider to be stakeholders in the product development process. Such individuals might include the following:

- Human factors specialists
- Industrial designers
- User interface designers (if not represented by the two above)
- Engineers
- Marketing specialists
- Project leaders
- Product managers

Some companies might also want to involve representatives of the intended user groups, such as advisory panel members or individuals recruited from specific types of institutions (e.g., nurses from hospitals). This approach is highly advised when there are standards and regulations calling for a user-centered development process, such as in the medical device industry. It is also a smart move when you are committed to a user-centered design process.

Assessment criteria that guide the down-selection process

The assessment criteria will be tailored to the product in development and presumably include items derived from user needs and preference findings. Of course, these criteria may also pertain to technological and business considerations such as level of effort to develop software code, whether the product as conceptualized can be built at target pricing, and competitive differentiation. Examples of user-oriented assessment criteria, which might apply to some but not all types of products, are presented below.

- Degree of user support
- Ease of maintenance
- Graphical appeal
- Initial ease of use
- Long-term ease of use
- Perceived simplicity
- Physical feel
- Portability
- Positive transfer of use experience
- Reliance on a user manual
- Reliance on training
- Task efficiency
- Time to develop mastery
- Safety features

The classic assessment approach is to choose perhaps 10 of the most important assessment criteria, to participate in briefings or demonstrations of the concepts, and then rate them according to the 10 criteria, which might be weighted to reflect their differing degrees of importance.

Effective user assessment of concepts

If a sample of intended users participates in the assessment, you may choose to follow the same assessment approach described above. However, keep in mind that you would be asking a lot of people who are not familiar with product development to internalize many assessment criteria and then consider dozens of concepts. Accordingly, you might want to conduct an initial internal assessment to down-select to a manageable number of concepts — perhaps six to eight of the most promising and/or diverse ones.

A particularly effective technique to engage intended users in concept assessment is called a cognitive walkthrough. The technique calls for the research participant to view images or physical models and discuss how they work. For example, a participant viewing a mobile app mockup on a phone might simply say what they would do, step-by-step, to work their way through a pertinent use scenario. The mockup may have built-in interactivity if it was created with a prototyping application. In lieu of an interactive prototype, the researcher would describe how the mobile app would respond to stated actions.

The assessment output: one concept versus two to three

The assessment work can point you toward the few or the one concept that best meets the assessment criteria. There are merits of taking two to three concepts to the next stage of development as opposed to focusing on one design path. For many product developers, taking two to three concepts into detailed design and engineering is a sensible hedge against making a bad decision regarding the most promising concept. After all, the single most promising concept might not look as good after a more intensive design and engineering effort. The counterargument is that there might be one obviously best concept to which committing at an early stage of development will save resources, presuming that the concept was fully vetted.

Subsequent Steps

While this paper is focused on conceptual design, you may value a summary of the subsequent user interface design steps. They normally include the following:

- **Detailed design** – Taking one or more design concepts from the "big idea" stage to the stage where feasibility may be proven or disproven. At this point a product's functionality has been resolved such that it can be assessed in a hands-on manner.
- **Modeling** – Building physical models of hardware and computer-based, interactive models of software (i.e., various screens). The purpose of the model(s) is to enable formative evaluations that produce reliable results.
- **Formative evaluation** – Using one or more techniques to collect user feedback and user-product interaction data that can be used to judge and refine a given design solution. If you turned multiple design concepts into multiple, detailed designs and prototyped them, this is the stage when you will determine which one is best, or where there is an opportunity to produce an optimal hybrid of two or more concepts.
- **Iterate** – Repeating the prior three steps as needed to converge on a single, refined solution. It is common for design programs to anticipate two to three iterative cycles and allow for more as needed.
- **Human factors validation testing** – Conducting a presumably final usability test to demonstrate that a production-equivalent prototype enables the intended users to interact safely and effectively with the product. This work is pivotal from a commercial standpoint, and it might be required by applicable regulations and a company's quality management system. A company might integrate design validation testing into this stage to confirm that the product's user interface is performing as specified, particularly with regard to a product's usability. As such, design validation testing dovetails with human factors validation testing of a product's user interface.

Summary + Conclusion

Conceptual design of a user interface is simultaneously a simple and complex endeavor. Perhaps this is because concepts are speculative in so many ways and are little more than a promise of what may be created rather than a physical or digital solution that works. Concepts can range widely in terms of their viability even if sketches and models look promising. Still, the conceptual design step is key to future success. Jumping rapidly into detailed design or a single concept forsakes the opportunity to take a design in a new, innovative direction. It also forsakes the opportunity for the intended users to help shape the concept.

The lesson for all product developers is to plan and execute a robust conceptual design effort. This opens the door for discovery and innovations that can drive a product's future success.

For more information about Human Factors Research & Design, visit us at HumanFactors.EmergobyUL.com.

About the authors

Michael Wiklund serves as General Manager of the Human Factors Research & Design (HFR&D) practice at Emergo by UL. Previously, he founded Wiklund Research & Design, a human factors consulting firm that UL acquired in 2012. He has over 30 years of experience in human factors engineering, much of which has focused on medical technology development – optimizing hardware and software user interfaces as well as user documentation. He is a Certified Human Factors Specialist and Licensed Professional Engineer. He is author, co-author, or editor of several books on human factors, including Writing Human Factors Test Plans and Reports for Medical Technology Development, Usability Testing of Medical Devices, Handbook of Human Factors in Medical Device Design, Medical Device Use Error – Root Cause Analysis, and Writing Human Factors Plans and Reports for Medical Technology Development. He is one of the primary authors of today's most pertinent standards and guidelines on human factors engineering of medical devices: AAMI HE75, IEC 62366-1, and IEC 62366-2. In addition to leading Emergo by UL's human factors engineering practice that now includes over 70 HFE and user interface design specialists, he is a Professor of the Practice at Tufts University where he teaches graduate courses on HFE, including applying HFE in medical technology development.

Cory Costantino is the Director of User Interface Design within the Human Factors Engineering group at Emergo by UL. Cory is a board certified human factors professional. He received his M.S. in Human Factors in Information Design from Bentley University and his B.S. in Industrial Design from Wentworth Institute of Technology. Cory oversees and contributes to a wide range of projects including software user interfaces, instructional materials, hardware/ergonomic design reviews, and multi-phase projects, where he often contributes to user research and usability testing. Cory has served as design director and co-founder of two start-up companies, an adjunct professor of design, and as a design consultant. For nearly 20 years, he has helped guide products, from hand-held consumer electronics to medical devices and software user interfaces, from concept to production. His unique and diverse experience enables him to deeply understand the intersection of client resources, user needs, and design vision.

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