Prototyping the Need

Just as you'll use prototyping to gain insights about your solution ideas (see the toolkit called Prototyping: Question and Plan), you can **prototype the need** to uncover important information during need research. The way this works is to ask questions about your need area and then design and build models and tests to address those questions. You then can use the results to catalyze additional research, modify your need statement, or refocus your overall efforts.

"Need prototypes" can be physical or mathematical models, computer simulations, or mock user experiences – anything you can make, build, or do to better understand your need. **What you build and test** should be directly informed by **what you want to learn**. And what you want to learn could be related to any of the key components of your need statement. For example:

- **Problem** – If you're working on a disease-based problem, what about the relevant anatomy or physiology is central to the need? Trying to build a basic physical or mathematical model of the normal physiology and/or the pathophysiology of the condition often can enhance your understanding or identify gaps in your knowledge. If you're working on a problem that's more behavioral or process-oriented, what could you learn by simulating that behavior or process? Sometimes simply creating multiple diagrams of your understanding of the workflow can highlight bottlenecks or enable you to refine your understanding, especially since such artifacts can be an effective tool for gathering concrete feedback from stakeholders/experts.

- **Population** – What's it like to be a member of the population targeted in your need statement? Teams have found that trying to act out or create a play-acted scene can help increase their empathy for individuals in the target group. What steps could you take to better appreciate your population's perspectives and priorities when they consider potential solutions?

- **Outcome** – What could you do to better understand the magnitude of the improvement in outcome(s) necessary to have a meaningful impact on the patient or another key stakeholder? Can you create a before/after physical model of the (patho)physiology? Perhaps you could "run the numbers" by creating a spreadsheet with different projected levels of outcome success and the related potential impact on different stakeholders?

Your prototyping of the need should help you increase your expertise in the area you're working and help convince you that the need is real and compelling. Using prototyping techniques at this stage in the process gives you additional hands-on tools to explore your need and gather information that can contribute to more impactful solutions down the line. And, sometimes the models of the need that you build can directly help you to develop tests of your future solution ideas.

Steps to Follow

When you're ready to start prototyping your need, there is a series of fundamental steps to follow, These steps are outlined below and described more extensively in the toolkits called Prototyping: Question and Plan, Prototyping: Build, and Prototyping: Test, Assess, and Iterate.

1. **Make a list of questions about your need** – Prototyping is question-driven and question-dependent. Although you may not end up with answers to all of your guiding

questions, without them your efforts to build/test a prototype and generate meaningful data likely will be inefficient and potentially unsuccessful.

2. **Prioritize questions by risk and relevance of prototyping** – Before you invest significant time and energy in any effort, it's a good idea to tackle the questions whose answers have the greatest potential to change the project's direction or to derail it entirely. Resist the temptation to emphasize the easiest questions to answer. Instead, prioritize questions based on how much risk they present to the project. Also, keep in mind that not every question about your need is ideally suited to prototyping – some will be better addressed through background research and validation interviews (see the Need Finding and Validation through Interviews toolkit). But think creatively, and challenge yourself to find ways to learn about tougher need-related questions with quick/simple prototyping. You'll be surprised how many questions can be prototyped efficiently, using methods like those described above and in the student examples below.
3. **Choose question(s) to address** – While you typically want to focus on one top-priority question to prototype, you may find that several questions overlap or address different aspects of the same theme. In those cases, you may be able to address multiple questions through a single prototype or series of prototypes.
4. **Make a plan** – Before doing anything, be sure you have a relatively thorough plan (at least a written outline of the specific steps, materials, etc.) for what you intend to build/do/test. Your plan should explicitly include what data you intend to generate that provides insight on the question.
5. **Build and test your prototype** – Now's the time to dive in and create your prototype! Execute your tests and gather/plot your data.
6. **Assess your results** – Analyze the data you've generated and draw conclusions. Based on what you've learned, you can update your questions list and determine the next steps to take based on your learnings. Consider taking your prototype/results to share in your next stakeholder interview. In some cases, an important next step may be to build another need prototype. If so, return to step 1 and start over again!

The following student examples illustrate different approaches to prototyping the need. Your efforts may not always lead to useful results (see Box 1). But, more often than not, you'll learn a great deal by applying these techniques to your project during need research.

Example: Chronic Wounds

When Priyanka Shrestha had the opportunity to do needs finding in the hospital setting, she observed a patient visiting the emergency department (ED) with an open wound that hadn't healed for nearly six months. "I was surprised how little they could do for her in the ED. The burden of care was clearly on the patient in the home setting," she said. Shrestha became interested in the healing of chronic wounds, such as reopened surgical wounds, pressure ulcers, and diabetic ulcers. She performed research to understand skin anatomy and the stages of normal wound healing. She also investigated the factors most likely to disrupt the healing process, including pressure, trauma, increased bacterial load, and inappropriate or insufficient care. And she looked into existing treatment options and how they were supposed to work.

Reading about all of these topics was useful, but Shrestha wanted to achieve a deeper level of knowledge, as well as greater empathy for patients with chronic wounds. "I wanted to feel the problem and see for myself how a wound might form and what could be the difficulties associated with treating it," she explained. So, as part of a class project, she set out to prototype an aspect of her need.

Questions: What does the structure of different stages of wounds look like in 3-dimensional space? How does it feel for patients to care for these wounds?

Plan: Build an anatomical model of a wound, larger than life-size, with different materials representing different layers of the wound:

- Model 5 different layers: epidermis, dermis, subcutaneous tissue, muscle, bone
  - Use anatomical references to create reasonably accurate (+/- 5 mm) thicknesses of each layer
  - Fascia layer = "Nice to have" stretch goal
- Choose materials with hardness/stiffness properties similar to each tissue layer
  - Epidermis = stretchy + thin fabric
  - Dermis = fabric
  - Subcutaneous tissue = silicone
  - Muscle = spongy foam?
  - Bone = plastic?
  - Fascia = plastic wrap?
- Size/shape: ~15cm diameter cylinder, ~10cm tall (with all layers)
- Steps:
  - Gather materials + cutting tools +/- glue/tape
    - How to attach layers? Staples? Glue?
  - Cut materials to size (simple stencil?)
    - Note: Need cutting surface if using box cutter
  - Assemble model layer by layer from bone to epidermis
  - Take pictures of side and top views
  - Measure/assess "squishiness" to see if it is reasonable for tissue mimic
    - Using force gauge, could measure depth versus force and compare with volunteer skin depression test in different parts of the body (arm versus thigh versus back versus stomach)
  - Create step-by-step wound from epidermis down to bone layer
    - Diameter ~2-3cm at surface
    - Take pictures at each level

Prototype: 3-dimensional model of chronic wound (Figure 1) and stages of chronic wound formation (Figure 2).

Insights:

- **Wound architecture and shape** – The fundamental structure of the wound is problematic. The wound is large and gaping at its outer layer but, as it gets deeper, the diameter gets smaller and more difficult to access and visualize. This makes more advanced wounds significantly more difficult to inspect, clean, and treat.

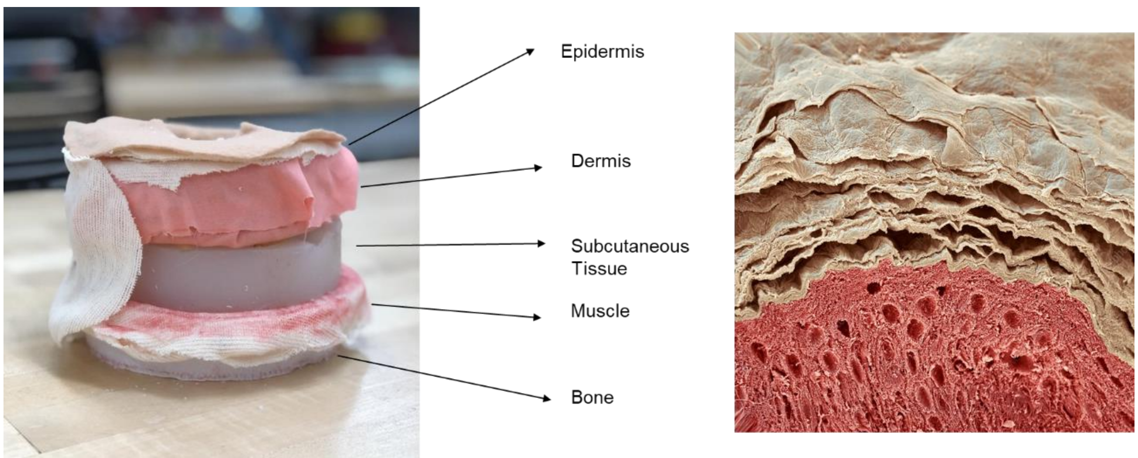
- **Difference in physical properties of the tissue layers of the wound** – The layers of a wound differ in terms of their thickness, hardness, and sensitivity. This could create the opportunity for different treatment mechanisms to heal different layers of a wound.

- **Empathy for the patient** – As Shrestha described, “It’s one thing to look at a picture of a chronic wound, and it’s another to stare down into the model and imagine seeing your own bone at the base of the wound. Since most wound care is done at home, I could imagine how hard this must be for patients and their care givers.”

Next Steps: Model a specific type of open wound, in the context of where that type of wound is likely to appear on the body (e.g., diabetic ulcers often occur on the bottom of patients’ feet) to help consider access, treatment, and care with that in mind.

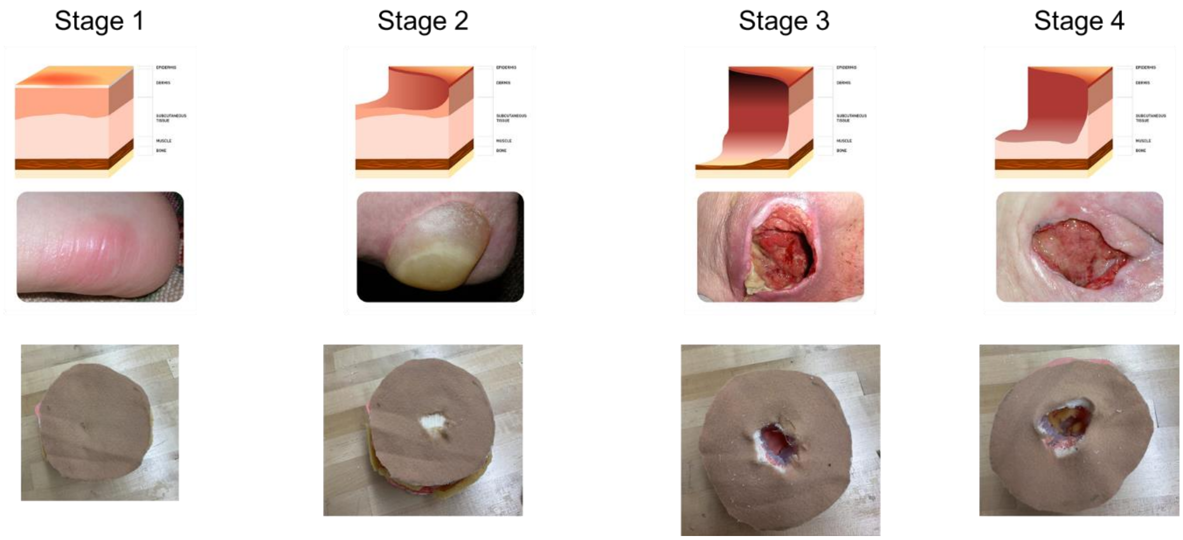
Reflecting on her need prototype, Shrestha noted, “I was initially really focused on thinking ahead to how I would come up with a novel innovation in the area of chronic wounds. But I realized that prototyping aspects of the need can be just as impactful because it gives you a new perspective on the problem you’re trying to solve.”

Figure 1 – Model of Chronic Wound



Using a detailed drawing of a chronic wound and some images taken under microscopy as a guide, Shrestha stacked different materials to represent each layer of a wound – for example, hard Styrofoam for the bone, silicon wrapped in fibrous cloth for the muscle, squishy silicon for the subcutaneous tissue, silicon covered in less porous cloth for the dermis, and thick felt sheets for the layers of the epidermis. She “scaled up” to make the model easier to build, but tried to be as accurate as possible in terms of representing the size of the layers relative to one another. Image courtesy of Priyanka Shrestha.

Figure 2 – The Stages of Chronic Wound Formation



To better understand how wounds form, Shrestha used an Exact-O knife to puncture each layer, using drawings and photos as a guide. At each layer, Shrestha took photographs and performed a visual inspection. Images courtesy of Priyanka Shrestha.

BOX 1

Redirecting When Prototyping Doesn't Go as Planned

When Alana Mermin-Bunnell visited a urology clinic, she was exposed to a patient with Peyronie's disease. This condition occurs when a fibrous plaque, containing excessive collagen, forms inside the penis and causes curved, painful erections. During the acute phase of the disease, which often lasts 6-12 months, scar tissue develops, creating curvature and discomfort. During the chronic phase, the plaque is no longer growing so the curvature doesn't get worse, but pain may continue. "It seemed like a painful and vulnerable condition for patients that was quite stigmatized," she noted.

Through her research, Mermin-Bunnell learned that the standard of care for this condition was a series of injections to breakdown the excess collagen – usually requiring eight painful sessions over the course of six months – which had a moderate success rate. A second option was surgery, which had a strong success rate but undesirable side effects, including loss of penile length. A third common treatment was traction therapy, which could be performed at home but was uncomfortable, with success rates varying by device. Reflecting on these treatments, she was struck by the lack of patient-friendly options. "The injections were painful, time consuming, and patients had to wait a long time for results. Surgery was effective but it was painful, too, and patients really didn't like the loss of length. Traction therapy offered mixed results and seemed archaic. All of the options required patients to make really undesirables trade-offs," she said.

When it came time to prototype the problem in class, Mermin-Bunnell explained, "My first thought was that I needed to make a physical object that I could manipulate and test to see what happens. So I decided to explore how pliable plaque might be." She had learned that the hardness of the plaque can vary from fleshy to calcified. This caused her to wonder if patients could benefit from different approaches to reversing curvature depending on the state of their plaque build-up. For an initial effort, she decided to test how long it would take to bend a variety of materials of different hardness 40 degrees, which is the average curve in patients. But, working in the classroom and under a specific timeline, her options were limited. "I didn't have any actual pieces of plaque and, in this situation, there wasn't time to do more research and create a compound that would accurately mimic plaque in different states. So I pulled things off the shelf, just to get started," she said. In this case, she used a pipe cleaner, an acrylic sheet, a fibula bone model, and a metal hanger. "What I was trying to show was fairly obvious – that the harder the material was, the longer it would take to bend. But the results were very inaccurate. I was using one hand to bend the material, while using the other to do the timing on my phone. And my hand positioning varied from material to material, so the results just weren't very useful," she explained (see Figure 3).

Figure 3 – Time to Bend to 40-Degrees

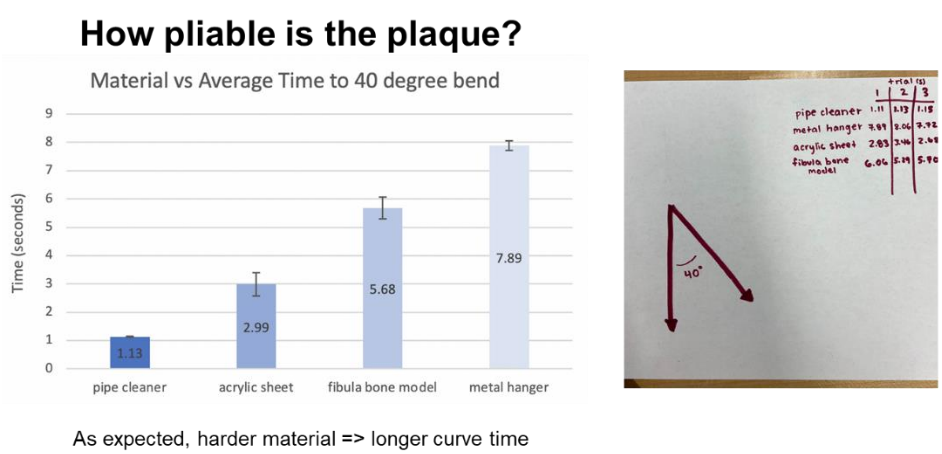
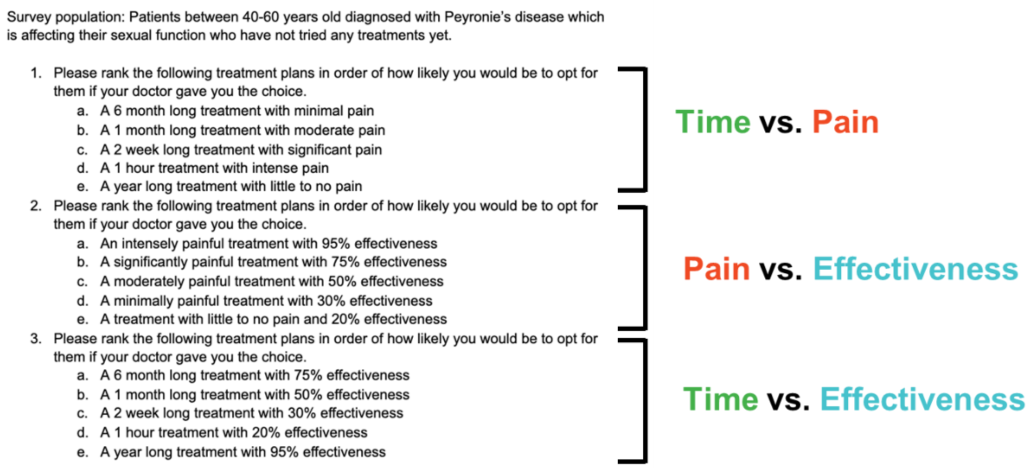


Image courtesy of Alana Mermin-Bunnell.

Unsatisfied with these results, Mermin-Bunnell started to think more broadly. She went back to her research on the trade-offs inherent in all of the currently available treatment options. That's when she decided that the question she really was most interested in answering was what patients would want out of an improved treatment. "It seemed like there were three variables: time, pain, and effectiveness," she explained, "with no current treatment able to deliver all of them. So I wanted to learn more about the ideal combination from the patient's point of view so I could use this information when it was time to start coming up with new solution ideas. Rather than trying to prototype this question with a physical device, Mermin-Bunnell decided to mock-up a survey that could be used to gather patient data. Based on how they responded, it would help her narrow down which tradeoffs they're most willing to make.

While she didn't have time to implement the survey (see Figure 4) within the constraints of her course, she still found the exercise useful.

Figure 4 – Mock Survey Questions Exploring Patient Preferences


Survey population: Patients between 40-60 years old diagnosed with Peyronie's disease which is affecting their sexual function who have not tried any treatments yet.

1. Please rank the following treatment plans in order of how likely you would be to opt for them if your doctor gave you the choice.
   a. A 6 month long treatment with minimal pain
   b. A 1 month long treatment with moderate pain
   c. A 2 week long treatment with significant pain
   d. A 1 hour treatment with intense pain
   e. A year long treatment with little to no pain
2. Please rank the following treatment plans in order of how likely you would be to opt for them if your doctor gave you the choice.
   a. An intensely painful treatment with 95% effectiveness
   b. A significantly painful treatment with 75% effectiveness
   c. A moderately painful treatment with 50% effectiveness
   d. A minimally painful treatment with 30% effectiveness
   e. A treatment with little to no pain and 20% effectiveness
3. Please rank the following treatment plans in order of how likely you would be to opt for them if your doctor gave you the choice.
   a. A 6 month long treatment with 75% effectiveness
   b. A 1 month long treatment with 50% effectiveness
   c. A 2 week long treatment with 30% effectiveness
   d. A 1 hour treatment with 20% effectiveness
   e. A year long treatment with 95% effectiveness

Image courtesy of Alana Mermin-Bunnell.

"Initially I was so focused on physical prototyping. But after some additional consideration, I think the data I could gather through a survey would be much more important for informing my understanding of the problem and, eventually, what new solutions could be most attractive and impactful in the need area," she said. (See the Need Finding and Validation through User Surveys toolkit for more information about gathering need-related information through surveys.)

Credits

This example was written by Lyn Denend, Ravi Pamnani, and Ross Venook. We'd like to thank Priyanka Shrestha and Alana Mermin-Bunnell for sharing the examples.