*Long before the assembly lines roll, industrial designers Ray Oyung and Max Pollock are filling sketchbooks with ideas and building mockups of new sequencers by hand. Photo by Kristy Walker*

# How Illumina designs a gene sequencer

*Four UX design staff share the ideas and innovations that became the MiSeq i100 Series*

*Illumina recently launched the MiSeq i100 and MiSeq i100 Plus Systems,* two powerful, compact benchtop sequencers that incorporate more than 140 invention disclosures and 60 patent families. On our News Center, we are celebrating outstanding employees who helped develop this breakthrough technology.*

EVERY HUMAN-MADE OBJECT WAS DESIGNED. This is as true for lab equipment as it is for shovels, soda cans, and wheelie-heel shoes. At some point, a designer considered how every detail of that thing will serve its end user. Poor design causes immediate friction. But when something simply works, it's easy to take for granted the effort that went into making that experience as smooth and error-free as possible.

At Illumina, few take on the customer's perspective more than our user experience (UX) designers—and every aspect of our newest sequencer, the MiSeq i100 Series, is the result of years of creative thinking, painstaking market and user research, and focused iteration.

Ray Oyung directs the human factors and industrial design team. His guiding principle is to ensure that customers can do everything they need to effectively, efficiently, and safely. Safety is crucial, considering that our products are often used for medical research. But his résumé is ironclad: He comes from a background in aerospace human factors, where he helped modernize air traffic control systems. From there he designed military medical equipment and vehicle systems, then radiation therapy systems and accessories, before coming to Illumina. He understands better than most how no matter is too small to deserve the same careful scrutiny.

Oyung works closely with Max Pollock, a classically trained industrial designer with a stack of sketchbooks on his desk. Long before the assembly lines roll, Pollock fills these books with ideas, imagining how every component of an instrument might look and fit together. From there, he collaborates with engineering and marketing teams to turn those sketches into reality, and gives creative direction to the brand team on packaging and other assets.

But these decisions aren't made in a vacuum—they all stem from customer needs. "What people get wrong about industrial design is, they think we just make it look pretty," Pollock says. "In truth, everyone on the team comes from a consulting background, and 'making it pretty' is honestly the shortest, easiest part—95% of our work is being the voice of the customer."

** illumina.com/systems/sequencing-platforms/miseq-i100.html*

**The voice of the customer: UX research**

Rachael Settipani brings a decade's worth of market research wisdom to Illumina's UX research team, and before products enter development, they talk to genomics customers to learn their wants and needs.

They began their work on the MiSeq i100 Series in 2021, by interviewing 16 companies and institutions in the low-throughput-sequencing space. The conversations were double-blind—neither the customers nor the Illumina researchers knew whom they were speaking to, ensuring that both the questions and the answers could be as candid as possible.

"We approach the research with a broad mindset," Settipani says. "We simply want to hear from customers, and for them to tell us their stories"—their research topics of interest, obstacles they face in their workday, their thoughts on their current sequencers. "I think the real key to doing good qualitative research is, we let the conversation go where it needs to. We allow the customers to speak their opinions without guiding them."

This qualitative research produces a list of several hundred insights that determine the questions Settipani's team asks in the next step: quantitative research. They cast a broader net, surveying 250 low-throughput customers in more extensive detail to prioritize what they'd want in a new sequencer.

Here, the UX researchers kept a lookout for two kinds of potential innovation: First, matters that aren't well satisfied in the market, but that customers consider important. These "focus areas" were obvious goals for the MiSeq i100 Series. Easy, intuitive operation was one—people should be able to run the instrument whether they're new to next-generation sequencing or an expert.

The second kind of potential innovation is matters that aren't well satisfied in the market, but that customers don't consider important. Companies ignore these "hidden opportunities" at their peril, Settipani says. As an example, she points to the original iPhone. Before it debuted, there was no demand for a combination cell phone, camera, and music player. "But then, when someone's able to meet all those needs, it catapults into a truly disruptive innovation."

One hidden opportunity the MiSeq i100 Series fulfilled was enabling customers to install the instrument themselves, without an Illumina field technician. Only a few qualitative interviews mentioned installation as a pain point—but when the UX research team presented the idea in their quantitative surveys, it surfaced as a hidden opportunity from all respondents.

PHOTO BY KRISTY WALKER

*"'Making it pretty' is honestly the shortest, easiest part," Pollock says. "95% of our work is being the voice of the customer."*

**To the drawing board: System architecture**

Once the UX research is in, Pollock's team works with Illumina's engineers to create the rough shape of the instrument, figuring out touch points that accommodate the range of users and the size of all necessary components.

Then they sketch ideas. Plenty of details remain to be fleshed out at this point. How will the light bar guide users through the workflow? How will they interact with the display, and how will they load and unload the cartridges? As they get a clearer picture of the system's architecture, they transition from pen on paper to modeling software. In parallel, they build full-scale mockups—with polyurethane foam blocks at first, followed by 3D prints, and later with aluminum and machined plastics.

The final mockups are "effectively real," Pollock says. They don't sequence, of course, but their compartments open as intended; the light bar works; and the screen displays the user interface in development. Throughout development, these models help the team assess human factors and evaluate the workflow to mitigate the risk of user error and solve the finest ergonomic details—how fast should the doors close after the button's pressed? How far should the spent-reagent bucket tilt out? How much should the screen tilt for users of different heights?

A major goal of the MiSeq i100 Series from the beginning was to have reagents that ship and store in ambient temperatures. "From that moment, we designed the cartridges to stack together in their bags," Pollock says. "So right from the get-go, we knew that if, for some reason, we couldn't get to ambient ship and store, it would still be useful for them to stack on top of each other nicely in a fridge." Ultimately, they succeeded on both counts—the reagents don't require refrigeration, and they stack, saving valuable shelf space.

PHOTO BY KRISTY WALKER

*MiSeq i100 Series reagent cartridges were designed to be easily disassembled, so individual parts can be recycled appropriately.*

**What you see is what you get: The graphical user interface**

As soon as the industrial designers define the instrument's display parameters, the software design team, led by Gordana Lamb, hits the ground running.

In her five years with Illumina, Lamb has worked on three different sequencers, and her background in computer science is invaluable to her communication with the software developers. Her work covers every part of how the user interacts with the instrument software. What should the text on each button say? What settings should be present on which screen? Which menu options lead where?

As they answer these questions, the team follows three golden rules. First, embody precision: There should be no ambiguity about what something does. Second, instill clarity: All functions should be intuitive—the user shouldn't have to wonder what will happen when they press a button. Third, create harmony: Every screen and tool should look like they belong together, flowing cohesively from one to the next.

Informed by customer research, a major goal for the MiSeq i100 Series interface was simplicity. Pursuing the hidden opportunity of self-installation, the software designers created a user-friendly instrument setup wizard with helpful illustrations. Then they observed alpha testing sessions with customers (conducted by the UX researchers), and used customer feedback to make additional improvements.

And of course, errors will still happen even in the most careful labs, so Lamb works with Illumina's technical writers to craft the clearest error messages possible, using consistent terms, in the appropriate professional tone. She explains, "You don't want to be too casual—like, 'Oops, something broke!'—because then the customers don't trust that you're taking things seriously. So we try to balance being friendly with being very precise about what's going on." This level of detail ensures that even if the user doesn't understand the problem, they can give technical support the information needed to find a solution.

PHOTO BY KRISTY WALKER

*The design of an Illumina sequencer undergoes several rounds of creative revision on its way to becoming a final product.*

**The proof is in the poka-yoke: Customer feedback**

The leads of every design team who worked on the MiSeq i100 Series are proud of the final product—especially when they hear anecdotes from its first customers about the new features they love. "It's been satisfying to look back at the research and say, 'Yes, we identified this as a strategic area to differentiate,'" Settipani says. "It's a good example of how, if you get involved with customers early, you have time to embed these ideas, test them, and make sure we're developing a product that'll be well received."

Oyung shares that, during alpha testing, one customer told him, "'I've been in this business for over 12 years, and this sequencer is the easiest I've ever worked with. I can't wait to have it in the lab.' So it was like a round trip, between what one set of customers had mentioned during research, and this validation at the end of our journey. That perspective is what makes me so inspired about being here, and the things we're doing together."

Pollock is proud of how much they simplified the instrument's entire workflow, which makes a big difference for labs that have limited experience with next-generation sequencing. They followed the engineering principle of poka-yoke, which is Japanese for

"mistake prevention"—for example, there's no wrong way to load MiSeq i100 Series cartridges, and their geometry naturally draws the eye to specific points where the user's thumbs should rest. Basically, he says, "if you put it in backwards, it doesn't even begin to fit."

In their day-to-day interactions, Illumina designers are often the only people in the room without a PhD. "That can be quite daunting," Pollock says. But it takes a broad spectrum of expertise to build a quality instrument. All cross-functional disciplines are integral to a successful product release—and UX design ensures the customer's needs can be met in a form that is both functional and beautiful.

"What we are good at is communicating," Pollock continues. "So while we don't know exactly how some fundamental concept of the chemistry may work, we can help illustrate the idea and turn it into something that people who don't have that expertise can understand." ◆