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Generative AI fuels creative physical product design but is no magic wand

Generative AI tools can shorten physical product design life cycles significantly and spark innovation, but the knowledge and discretion of design experts are necessary to mitigate potential pitfalls.

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Although generative AI (gen AI) is in its infancy, the technology is already leaving an indelible mark on how physical products and packaging are conceived, innovated, and designed.

From product packaging to car components and retail displays, gen AI enables industrial designers to explore more ideas and product experiences, including previously unimagined ones, and develop initial design concepts significantly faster than with traditional methods.

Additionally, with the ability to visualize concepts in high fidelity much earlier in the design process, companies can elicit more precise feedback from consumers as they work to fine-tune every element of the user experience (see images below). In product research and design alone, McKinsey estimates gen AI could unlock $60 billion in productivity.[1]

High-fidelity concept images of modern welding helmets powered by the Internet of Things that were created using a generative AI text-to-image software. Through iterative prompting, the industrial designer refined the initial designs to develop concept images with a futuristic aesthetic inspired by modern sports car styling. (Images are illustrative and were developed for this article.)

While gen AI tools can bring about extraordinary outputs, they cannot replace human expertise. Just as the industry saw with the arrival of computer-aided design (CAD) and later advancements such as 3-D printing and augmented and virtual reality, while the methods for designing physical products may change, design experts are needed to ensure the meaningful use of the technology and delivery of business value.

In the case of industrial design, experts conducting consumer research often unearth important insights that inspire pivotal design choices. Their skill in identifying the best concepts from the dozens of AI-generated images—assessing outputs with an eye for aesthetics and manufacturability and manipulating images based on user research and their design sense—is crucial in providing a final design that will resonate with users.

[1] "The economic potential of generative AI: The next productivity frontier," McKinsey, June 14, 2023.

Although these tools are relatively new, our teams continue to see their significant impact on productivity. When they are used properly throughout the product development life cycle, we sometimes see a reduction upward of 70 percent in product development cycle times, providing teams with the opportunity to spend more time conducting consumer testing, refining designs, vetting suppliers, and optimizing designs for manufacturability and sustainability. These tools and processes are ultimately a vehicle for growth and innovation, enabling faster development of far better products.

But while R&D and product development leaders can use the technology today to propel innovation, they will need to understand and prepare for the technology's limitations. In this article, we share ways gen AI can unlock creativity and productivity across the product development life cycle, examine crucial considerations for business leaders trying to create business value, and suggest steps for getting started based on our design work and the use of gen AI tools in our creative process.

Unlocking creativity and productivity across the design life cycle

When industrial designers create concepts or redesign packaging, consumer durables, experiences, spaces, or just about anything else, their creative processes generally go through a few essential phases: market and user research, concept development, and concept testing and refinement. Gen AI technology can provide tremendous value at each stage, enabling designers to iterate faster, connect the dots in new ways, and catalyze divergent thinking to create products that transform users' everyday experiences (exhibit).

Exhibit

Generative AI ushers in a new era of creativity and productivity across the product design life cycle.

Market and user research
Can reveal untapped market opportunities and overlooked consumer needs and expectations

Enables teams to gather, synthesize, and make sense of market and consumer data faster

Concept development
Ability to generate novel, lifelike images sparks bolder exploration and potentially first-of-their-kind ideas

Frees industrial designers of time-consuming tasks when preparing concept images, mood boards, and storyboards

Concept refinement
Enables industrial designers to refine product style and map future concepts in hours instead of weeks

Concept testing
Brings new concepts to life for business leaders and consumers for more meaningful discussions

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Market and user research

Almost all good physical product design starts with market research. What features or qualities are most important to potential consumers? How are consumer preferences and tastes evolving and how are our competitors responding? What gaps exist for creating a new category of offerings?

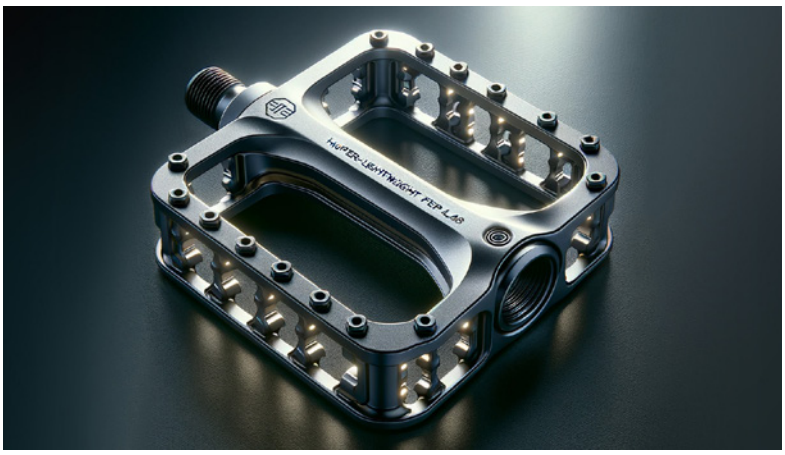
Using gen AI tools trained on large language models—such as ChatGPT, Bard, and others—designers can gather, synthesize, and make sense of existing market and consumer data far more expediently than previously possible. Moreover, because the tools draw insights from many more diverse data sources than humans alone could analyze, they can reveal untapped market opportunities and overlooked consumer needs or expectations. That enables industrial designers to build a much richer baseline of knowledge for stakeholder discussions and consumer interviews. One consumer packaged goods company augmented its market and user research with new insights from gen AI tools about consumer sentiment and how it might use its brand equity to expand into high-growth markets. With this knowledge, the design team broadened the scope of its ethnographic interviews, gaining feedback on important design elements that informed its subsequent work to develop and refine new concepts.

Concept development

As industrial designers and engineers create new product designs or iterate on the next generation of an existing product or engineering component, text-to-image gen AI tools provide a powerful medium for inspiration and innovation.

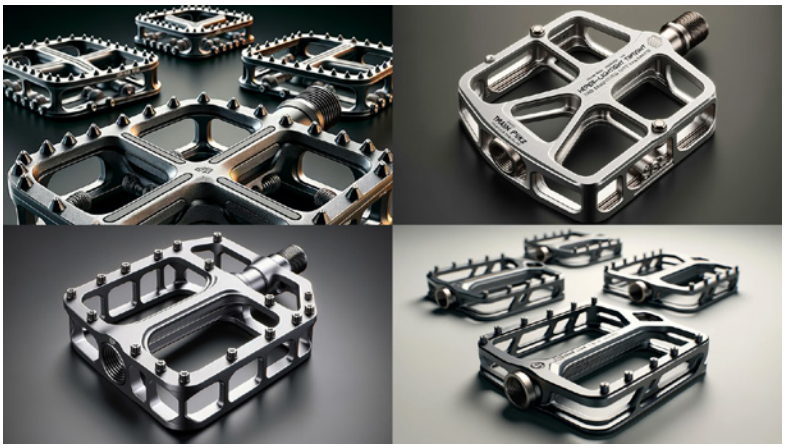
The technology's ability to generate novel, lifelike images based on expert prompts can inspire bolder exploration and bring forward distinctive and potentially first-of-their-kind ideas. These visualizations, data, and other outputs that emerge as designers input rough sketches, ethnographic research insights, and features based on consumer sentiment into a gen AI tool can be a great starting point, drastically accelerating the concept development phase. That said, human intervention by an expert designer is still needed to validate, test, and refine outputs to make them meaningful, manufacturable, and impactful, as the images generated typically can't be used in their initial state (for instance, some may not align with the company's vision, others may not reflect the designer's prompt in any meaningful way, and others still may be completely unmanufacturable).

As with previous technological evolutions, such as the emergence of CAD and 3-D printing, gen AI frees design experts from mundane and time-consuming tasks when preparing concept images, mood boards, and storyboards. By inputting iterative prompts about target performance goals and new specifications, for example, industrial designers can arrive at the "best answer" faster than if they tested different theories individually and then conducted highly manual due diligence (see images below).



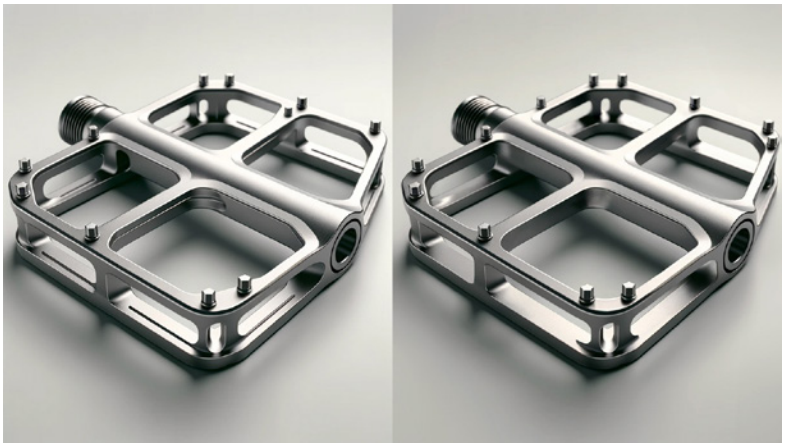
Initial prompt

A starting concept for a new bicycle pedal design produced using generative AI text-to-image software and developed based on initial guidelines from an industrial engineer. This represents the first phase of an iterative process to more quickly identify the best design approach for meeting specific performance and product specifications.



Prompt progression

Based on the software's initial output, an industrial designer then used iterative prompts to identify ways to reduce the amount of titanium in the pedal (thus making the pedal lighter) while improving component strength. Images illustrate the progression of concepts developed as the designer worked to finalize the raw output from the generative AI text-to-image software.



Final, refined, and manufacturable

The designer then refined the final raw output (on left) using image-editing software. To create the final concept (shown on right), the designer removed excess studs, adjusted the pedal braces to increase component strength, and made other adjustments to ensure manufacturability. (Images are illustrative and were developed specifically for this article.)

Industrial designers at an automotive OEM needed just two hours with the help of gen AI to create the initial design concepts for 25 variations of a next-gen car dashboard with a touch screen interface, charging surfaces, instrument panel, and other components. These concepts were then further refined by the design team using an image-editing software to provide stakeholders with a clearer picture of where the industry was going and how to evolve component interfaces, form factor, color, material, finish, and more for the latest models of electric vehicles (see images below). Without gen AI, creating images with similar detail and quality would have taken at least a week with many more iterations. This process empowered designers to bring a product experience to life in a far more tangible manner and in a fraction of the time.

On the left, an image of a traditional car interior. On the right, a final high-fidelity image of a new design concept for a next-gen electric-vehicle interior, using the traditional car interior image as inspiration. To develop the new concept image, the industrial designer used iterative prompts in an image generator, detailing the desired features (large touch screen, premium materials, and so on) to create the updated interior. The designer then refined the output using image-editing software to create the final image. (The final image is illustrative and was developed specifically for this article.)

Given that gen AI outputs currently require significant manipulation, the creation of these images typically happens in the studio. But as the technology develops and its outputs become more refined, industrial designers and engineers are increasingly sitting in meetings with business leaders and conducting consumer research sessions while using gen AI tools to create inspirational images in real time based on live feedback.

Concept testing and refinement

With the ability to elevate a conceptual napkin sketch or rough design idea to an immersive visual, industrial designers can also bring new concepts and experiences to life. This can enable more meaningful discussions with business leaders and consumers as they seek feedback on potential opportunity areas, concepts, and future visions.

Executives at a preeminent museum, for instance, could better visualize opportunities to increase accessibility of museum exhibits when industrial designers edited and combined AI-generated images with supplementary visual content (sketches, graphics, and so on) to create storyboards that illustrated novel formats, products, services, and experiences (see image below).

An AI-generated conceptual image refined through an image-editing software that depicts a virtual, immersive, and engaging educational environment for museum visitors. (Image is illustrative and was developed specifically for this article.)

Following the testing of initial concepts with stakeholders, designers can then use the technology to refine product style, apply finishing touches, and map future concepts to inform product road maps—sometimes in hours instead of weeks—before moving to the subsequent phases of design detailing, refinement, engineering concepts, and design for manufacturing.

Beyond design

Leaders seeking to further use the technology in product simulation and testing should watch the gen AI space closely. The technology is rapidly evolving, and as it does, we anticipate even more capabilities will become available to simplify the handoff between design and engineering and dramatically accelerate engineering processes. We're already seeing the market launch of gen AI software solutions that enable industrial designers and engineers to rapidly turn product concepts into CAD models. That allows them to model products far faster and begin the engineering process more expediently. While the tools are still nascent, we can imagine in the not-too-distant future that these tools will drastically improve and accelerate design-to-engineering handovers.

We also expect to see new tools capable of rapidly analyzing designs for manufacturability and serviceability—for example, to confirm whether a product can be manufactured using a facility's existing injection molding tools. From an engineering perspective, gen AI is already revolutionizing the way experts approach long-established simulation engineering problems, such as how to optimize the structural performance of products. One gen AI

tool for finite element analysis and topological optimization—cornerstone techniques for understanding how a part performs under different conditions and how to produce lightweight yet strong structures—can generate hundreds of improved-design options for parts based on identified criteria, such as forces, pressures, and environmental conditions. In the future, we can expect an even more comprehensive range of capabilities from such tools, including the abilities to transform rough sketches into detailed engineering part models, facilitate material selection and optimization, and identify ways to enhance manufacturability, optimize components for assembly, and reduce costs.

Crucial considerations for achieving business value

Without a doubt, gen AI outputs can be impressive. However, producing meaningful outputs and turning them into a desirable, user-centric, manufacturable product that matches user preferences, pain points, and expectations doesn't happen by just pressing a button. To achieve business value, industrial design and engineering expertise are crucial in the following areas:

— *Conducting consumer research.* Consumer research gleaned from gen AI tools may seem comprehensive; however, these tools can provide incorrect information (often called hallucinations). Additionally, even when the insights provided are accurate, they can offer only a baseline of knowledge, as consumer trends and behavior often change faster than training data sets. As a result, design teams must still verify hypotheses and investigate emerging trends through primary research. By combining gen-AI-produced insights and ethnographic interviews, design teams can obtain a much richer understanding of user preferences than either can provide on their own in the same period.

— *Developing effective prompts.* Highly iterative prompting is required to produce something close to what designers envision, consumers want, and companies can manufacture. A simple sentence may generate an interesting image, but the output won't necessarily be accurate, feasible, or relevant (see images below). Ultimately, design experts must provide context for the overall concept, including subject, medium, environment, lighting, color, mood,

Design experts are needed to develop effective prompts, as shown in these two AI-generated images of a girl painting a flower. On the left, the image depicts a girl painting the petals of an actual flower and was generated using a basic prompt suggested by a large language model chatbot. On the right, the image depicts a girl painting a flower on a canvas and was generated using iterative prompts from a designer. (Images are illustrative and were developed specifically for this article.)

and composition. They need to determine how much detail to include (for instance, less detail might produce more variety but result in concepts that don't have the specific features needed). What's more, they need to consider prompt length and how to separate complex prompts (having fewer words in a prompt means each word has more influence, which can affect outputs).

— *Refining gen AI outputs.* Oftentimes, text-to-image tools generate flawed images: a rogue plant grows out of the top of a television, or an unflyable drone is created (see image below). Organizations should expect to perform substantial postproduction editing—for instance, by using image-editing software to fine-tune the colors, fonts, and patterns used in the final concepts—to achieve a meaningful result. Even when initial outputs look as though they could be on store shelves today, closer inspection typically finds they are a far cry from a manufacturable product. Today, designers and engineers must still create their refined version of a concept in CAD to ensure the product accounts for manufacturing specifications, requirements, and constraints.

— *Curating the best concepts.* Gen AI can produce dozens of concepts quickly, but as the famous "jam experiment" study showed, too many choices can overwhelm both important stakeholders and consumers. As a result, organizations will need design experts to identify the best ideas from the large number of images produced and refine them based on aesthetics, feasibility, fit for use, and more to ensure concept testing with users yields valuable feedback.

— *Adding a good dose of human empathy.* AI tools are only as good as the data they are trained on. And given the "averaging" that may occur with aggregated inputs, they can perpetuate historical biases, oversimplify solutions, and gloss over insightful bits of nuanced human behavior that can provide the seeds for innovation. Industrial designers and engineers, therefore, must provide ongoing oversight of the design, making certain that all facets of product use are considered—from the aesthetics (whether the design is aligned with regional and cultural preferences) to ergonomics (whether the gen AI output is too large or unwieldy for the target audience) and usability (for instance, whether the product is accessible for individuals with disabilities).

An unflyable and not manufacturable passenger drone produced by an AI-powered image generator. Note the uneven number of propeller blades, insufficient landing gear skids, and lack of doors for passenger safety. (Image is illustrative and was developed specifically for this article.)

Getting started

Adding gen AI to the physical product design tool kit can accelerate and advance product design innovation, but only if teams can effectively use the technology. Based on our work and experience using the tools, we recommend R&D and product leaders consider the following actions to begin building their gen AI capabilities:

— *Set aside time for learning and exploration.* This action can involve empowering teams to test the technology in commonplace activities, such as iterating on new product features for an existing offering. It should also involve providing opportunities, such as a dedicated messaging channel or team meetings, to share successes and challenges. In other areas, such as software development, McKinsey research has found that the more practitioners use the tools and share their learnings with others, the better they get. We find the same is true in physical product design.

— *Identify and launch a pilot in high-value domains.* While it can be tempting to apply the technology to every project under way, leaders are best served by identifying a pilot project where there's potential to generate considerable value. A pilot project could use gen AI across the design life cycle for a signature product, or it could focus on streamlining one process, such as research, across its entire flagship product line.

— *Evaluate risks and institute guardrails.* Gen AI introduces new legal, ethical, and reputational risks that leaders must carefully consider and manage. These include concerns about data security (whether confidential information is being exposed when prompting the tool), intellectual property (whether the model outputs infringe on copyrighted, trademarked, patented, or otherwise legally protected material), and reliability (whether the tools are hallucinating and providing inaccurate responses to prompts), among others. In certain instances, such as gen AI's capacity to hallucinate, the risks may be limited, as design experts typically vet and verify information provided by the tools and marry it with additional primary data sources. Furthermore, any surreal and fictitious image generated by the tools during concept development may be an asset, inspiring greater creativity and originality.

In other instances, especially those related to intellectual property rights and data security, action is required to ensure the responsible use of the technology. Leaders should review their legal processes and design standards to confirm they have the necessary diligence measures in place to ensure a final product doesn't improperly reproduce third-party intellectual property, regardless of where their teams draw inspiration from—be it gen AI tools or their own research on- and offline. (In cases where teams wish to share AI-generated images they produce as is, leaders should ensure they understand intellectual property and ownership terms put forth by different tooling vendors as well as any relevant local laws that may govern ownership of an AI-generated output.)

Leaders should also implement policies that guide teams on what information can and cannot be used in gen AI prompts. Some best practices include understanding the terms of service for the given gen AI tool and refraining from using third-party intellectual property, proprietary insights, or other sensitive information in prompts.

— *Educate business stakeholders on new processes.* The level of detail and refinement of AI-generated images can create the impression that a product is much closer to completion than it is. As a result, as R&D organizations adopt these tools, they should be transparent about their use and provide stakeholders with a clear understanding of what the images represent, their use, and their limitations. Regular updates about the actual progress of a project can also ensure that the highly realistic visual representations don't lead to overoptimistic expectations.

— *Upskill industrial designers for future roles.* Using gen AI in physical product design will invariably create new roles wherein design

experts become “curators of creativity,” linking, manipulating, and drawing inspiration from the technology’s outputs to solve product challenges. This role requires storytelling and human-centered design skills, manufacturing know-how, competencies in other digital tools (such as CAD, illustration, sketching, and rendering software), a deep understanding of the use of different materials in design, and so on. It can take years to master these skills and understand how and when to pair with gen AI tools; as such, leaders should begin upskilling their teams today.

Gen AI has begun to reshape physical product design, enabling industrial designers to be more productive, creative, and strategic in building products that solve user needs. While the technology’s outputs can be dazzling, its ability to create business value becomes apparent only when combined with the skilled hands and discerning eyes of design experts. As adoption gains speed and as more designers and engineers integrate this technology into their workflows, we could see some genuinely revolutionary design and engineering solutions blossom. This will potentially lead to an entirely new aesthetic era with ingenious form factors, greater efficiency in material usage and manufacturability, and improved product life spans—benefiting both the companies that create these products and the people who use them.

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