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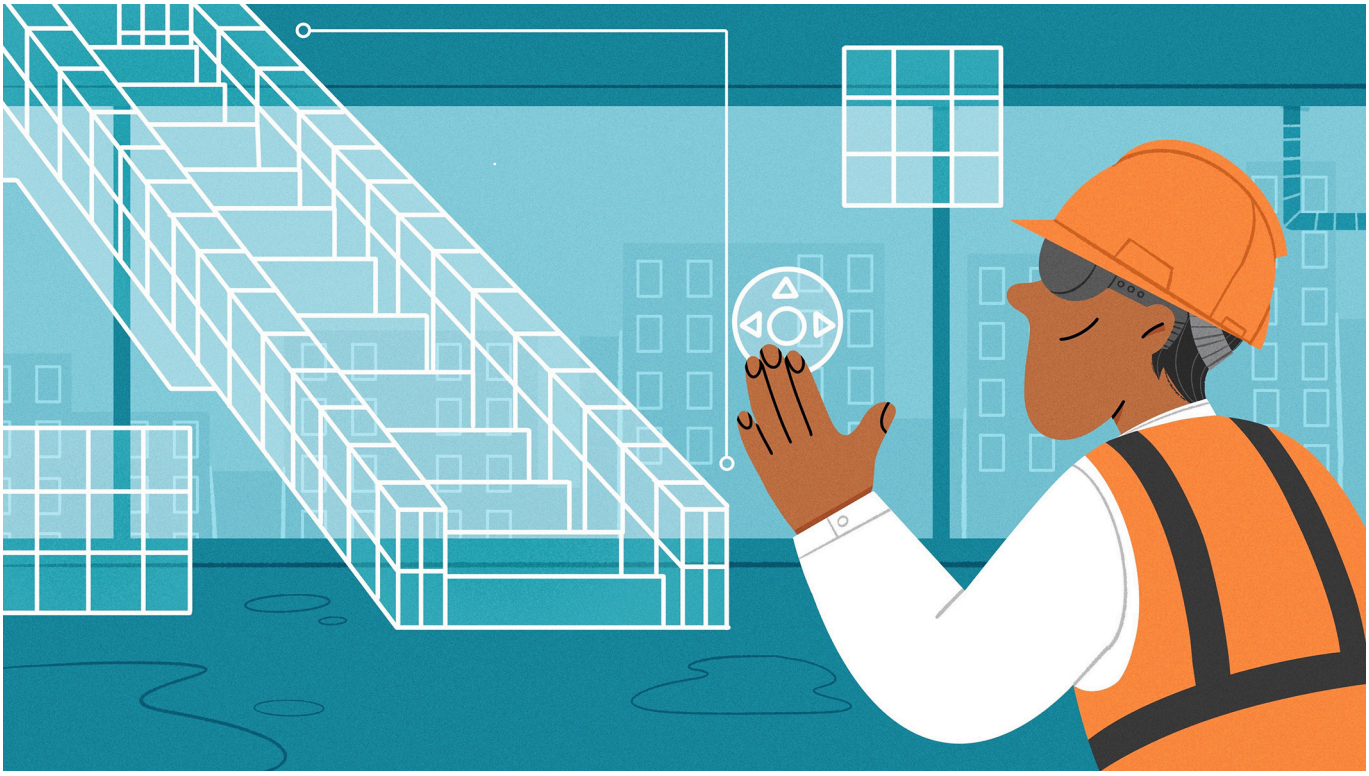

BUILDING BETTER WITH VIRTUAL TOOLS

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YOUNG REVIEWERS:

ADHITYA
AGE: 10

PRATHISH
AGE: 11

Computer-based technologies called immersive design tools are changing how construction projects are planned and built. These technologies allow builders to test ideas, solve problems, and improve designs in the virtual world, before using any real materials or spending lots of time. For example, architects could explore digital blueprints to spot issues early, and builders wearing special glasses could see virtual instructions as they look at a building, reducing mistakes. Cities could use these tools to plan major projects, like subway systems. Immersive design tools can also train construction workers in realistic digital environments, teaching them new skills safely. While virtual tools could make building more efficient, challenges like high costs, privacy concerns, and potential changes to construction jobs still need to be addressed. With continued creativity, virtual tools could make construction faster, safer, and

better for the planet, transforming how we shape the spaces where we live, work, and play.

THE WORLD NEEDS BETTER CONSTRUCTION METHODS

From homes to schools to skyscrapers, the built environment is all around us—and we could not live without it! Construction is one of the world's largest industries, shaping the spaces where we live, work, and play. But this industry also has a massive impact on the planet, contributing 40% of global CO_2 emissions [1]. Why is construction so harmful to the environment? A lot of the emissions come from producing and transporting construction materials like concrete, steel, and glass, which require enormous amounts of energy to manufacture. Then there is the waste: leftover materials, construction mistakes, and inefficiencies in the building process create tons of debris, much of which ends up in landfills.

The construction process itself can also be slow, expensive, and prone to errors. For example, if designs are unclear or mistakes are not caught early, builders may need to redo parts of a project, wasting time and materials. These inefficiencies drive up costs and delay completion. At the same time, the construction industry does not have enough workers available, so meeting deadlines and maintaining quality is becoming harder than ever. Builders need tools to help them work faster and more efficiently while reducing their impact on the planet. These challenges call for smarter solutions to streamline the building process and make it more sustainable. What if there was a way to build faster, more efficiently, and with less waste?

EMERGING TECHNOLOGY: IMMERSIVE DESIGN TOOLS

Immersive technologies combine the physical and digital worlds, allowing people to interact with virtual spaces as if they were real. These tools could transform the way construction professionals plan and carry out projects. Some examples include **virtual reality (VR)**, **augmented reality (AR)**, **digital twins**, and **generative AI**.

You might already know about VR video games, where wearing a special headset allows you to "step into" a digital world and explore it as if you were really there. In construction, VR could help architects "walk through" a building's digital blueprint, to test their ideas or spot potential design problems or safety risks, long before any materials are used. AR works similarly but blends digital information with the real world—kind of the way Pokémon GO overlays digital game characters on real-world locations. Using AR glasses, builders could see virtual instructions overlaid on the physical construction site—for example,

IMMERSIVE TECHNOLOGIES

Tools that combine the physical and digital worlds, letting people interact with virtual spaces as if they were real.

VIRTUAL REALITY (VR)

A digital world you can explore and interact with using special equipment, like a headset.

AUGMENTED REALITY (AR)

Technology that adds digital information, like virtual instructions, to the real world, often through glasses or a screen.

DIGITAL TWINS

Virtual copies of real-world objects, systems, or spaces, updated with live data to help people test ideas and solve problems.

GENERATIVE AI

A type of artificial intelligence that creates new things, like 3D building designs or art, based on simple instructions.

telling them where to place a wall or lay wiring—to make sure that every step follows the plan.

Digital twins take this even further by creating a virtual copy of a real object, system, or space. Digital twins are used in many fields—everything from medicine, where digital twins of the human body can help doctors, to construction, where they can track the progress of a project (to read about a digital twin of the Earth used to predict flooding, see this article). These digital models can be updated with live data, helping people understand, improve, and manage complex systems. A digital twin of a bridge, for example, could be updated with live data from sensors on the actual bridge, tracking construction progress and identifying potential weak points, helping engineers to fix problems before they happen. By allowing builders to test ideas and solve problems virtually, digital twins save time, materials, and money.

Generative AI is also changing construction design [2]. You might already know about this technology from apps or programs like ChatGPT that create pictures, write stories, or generate computer code. In construction, generative AI can take simple text descriptions and turn them into detailed 3D building models. For example, typing "Create a 10-story office building with solar panels on the roof" into a generative AI program could generate a complete design with construction details and safety features. Like the other tools we have discussed, generative AI allows teams to try out ideas digitally before using any resources, making the design process faster and more efficient—especially for smaller projects or teams with limited resources [3].

TECH TO THE RESCUE

Immersive technology is already solving real-world problems in the construction industry, helping to save materials and time (Figure 1). In cities, digital twins are being used to test ideas for large, expensive **infrastructure** projects before construction begins. For example, a city planning a new subway system could create a virtual model of the entire network to see how it would handle rush-hour crowds or extreme weather. A digital twin of a skyscraper could show where materials are being wasted or where construction delays are likely to happen. Engineers can use this information to spot problems and adjust their plans, keeping projects on track and saving money.

INFRASTRUCTURE

The basic systems, like roads, bridges, and buildings, that a community or city needs to function.

Inspections are another area where immersive technology could make a big difference. Inspections are a crucial part of construction, ensuring that buildings and other structures are safe and meet all necessary standards. However, inspections can be incredibly time consuming, often requiring workers to travel long distances to visit multiple sites. In Japan, for example, one construction company estimates its workers

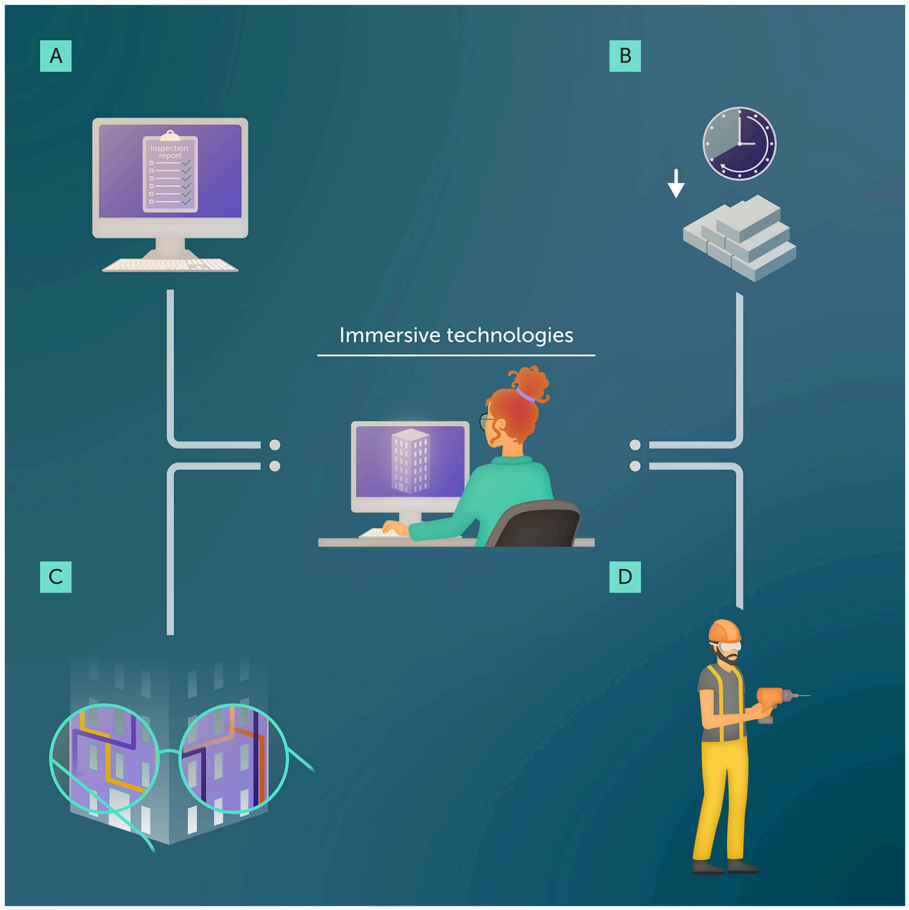

Figure 1

Immersive technology could solve many problems in the construction industry. For example: **(A)** inspecting buildings for safety takes a lot of time, and remote inspections could speed up the process. **(B)** Digital twins could help engineers spot potential problems and adjust their plans, saving materials and time. **(C)** AR glasses could allow builders to see virtual instructions, like where to lay pipes or wires, when they look at the real-life construction site. **(D)** VR simulations could be used to train workers on how to use tools and equipment before they even step onto a construction site, speeding up training and improving safety.

spend about 1 million hours each year traveling for inspections! Immersive technologies could allow workers to inspect construction sites remotely, from anywhere, saving time and letting experts focus on other tasks.

The construction industry is also dealing with a labor shortage, which means there are not enough skilled workers to meet the growing demand for new buildings and infrastructure. In the United States alone, hundreds of thousands of additional workers will be needed in the coming years to keep up with demand [4]. This shortage increases costs and makes it harder to complete projects on time. Immersive technologies could help by transforming how workers are trained. VR simulations let trainees practice skills in a realistic digital environment, no matter where they are. For example, a new builder could learn how to install wiring or operate heavy machinery before even stepping into a real construction site. This speeds up training, makes the work safer, and ensures workers are better prepared for the challenges of their jobs.

BIG CHALLENGES, BIGGER OPPORTUNITIES

As promising as immersive construction technologies sound, there are still challenges to overcome. One big issue is cost. Immersive technologies can be expensive, which might make them difficult to use in smaller construction firms or developing countries. Privacy is another concern, especially when digital twins are used to monitor real-world buildings. These models might collect sensitive data, like information about building security systems or the activities of people inside, which needs to be kept secure. Experts must figure out how to ensure this technology is used responsibly and ethically.

Another challenge is how immersive technologies will change jobs in the construction industry. Some tasks that skilled construction professionals do today might become automated by immersive technologies, which means workers will need to learn new skills to stay in the field. Training programs will be important to help people adapt and take advantage of the new opportunities immersive technologies create.

Despite these challenges, immersive technologies could change the way we build, for the better—helping to avoid costly mistakes, reduce waste, improve efficiency, and make training of construction professionals more accessible. With continued innovation and collaboration, these tools could create a more sustainable and connected future for the construction industry.

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YOUNG REVIEWERS

ADHITYA, AGE: 10
Meet a 10-year-old science wizard with a brain full of crazy experiments and a heart full of video games! 🚀🔬 When I am not busy figuring out how the universe works, you will find me battling bosses, building worlds, or asking way too many "what if" questions. Warning: I might accidentally turn my room into a mini lab (again)!

PRATHISH, AGE: 11
Prathish is an interesting 11-year-old who really likes science and fiction. He is a creative thinker and often comes up with ideas that make other people think differently. Stories about how new inventions were created especially grab his attention. He feels happier and more engaged at school than he sometimes does at

home. When it comes to sports, Prathish enjoys playing both cricket and badminton. Even though he can be a bit lazy sometimes, he has big dreams for what he wants to achieve in his life. This particular young man is also quite popular among his classmates.

AUTHORS

CARLO RATTI

Carlo Ratti is a professor at the Massachusetts Institute of Technology (MIT), where he studies how technology can improve cities. He leads a team that designs smart ways to make buildings, roads, and public spaces more helpful, green, and fun to use. Carlo has worked on projects around the world, from intelligent street systems to buildings that respond to people's movements. He also runs a design studio in Italy and often shares ideas about the future of cities at global events. When he is not teaching or designing, Carlo enjoys thinking about how digital tools can make city life better for everyone.

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Landry Signé is a professor at Arizona State University, where he teaches about leadership, innovation, and how countries and businesses can grow in smart and fair ways. He works at the Thunderbird School of Global Management, helping people around the world learn how to build better futures using new ideas and technologies. Landry has advised presidents, led international projects, and written books about how to create positive change. He is especially passionate about helping communities in Africa and beyond build stronger economies and embrace digital tools. When he is not teaching or speaking at global events, he enjoys sharing big ideas to inspire the next generation of leaders.

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