

# Back To The Future

**Geologists at Imperial  
College London use 3D  
video game technology  
to enable virtual fieldwork.**



## Imperial College London

**With the help of Toptal developers,  
faculty leaders launched a cutting-  
edge remote learning platform in  
just three months.**

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**We were able to deliver all the teaching we needed to during the pandemic in ways that were impossible 6 months before.**

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Mark Sutton  
Director of Undergraduate  
Studies, Imperial College  
London

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## The Client

Imperial College London is a science-based public university that is known for its excellence in teaching and research.

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## The Challenge

When shelter-in-place orders made geological field trips impossible, resourceful professors set out to create a 3D multi-user gaming environment to simulate fieldwork.

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## The Services

Toptal Developers

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## The Result

Leveraging Unity development expertise from Toptal's vast talent pool, the professors created an immersive 3D environment that gave geology students a collaborative learning experience that was the next best thing to being there.

# Seeing the world through science

**From the time they first enter a classroom, most students look forward to field trips. Undergraduate students in the Department of Earth Science and Engineering at Imperial College London have a good reason. The trips they expect to embark upon are critical to skill acquisition in their field.**

“We take students out for 100 days or so of fieldwork for a four-year degree, mostly to Europe,” explains geoscientist Mark Sutton, Director of Undergraduate Studies in the department for the last four years. “They spend time looking at rocks, sketching them, describing them, measuring them, and learning the key geological skills. Students gain these skills by actually being in close proximity to real rocks,

because that’s our real data.” He compares the geology students’ need for time in the field to a chemist’s need for time in a lab.

“To study the history of the earth, the only really good evidence we have is the rocks. You have to go look at them, so that’s a core part of what we do.”

Sutton recently surveyed his students to learn what drew them to earth science. Unsurprisingly, fieldwork came up first. “Fieldwork, travel, and seeing the world are the things people come into these areas for,” he explains. “That and just the mix of different sciences that are involved. In geology, obviously they’re learning about rocks, but there’s a bunch of physics, chemistry, biology. It mixes

everything together in a very practical way. The students are very keen to get outdoors and see it all in its natural habitat.”

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Director of Undergraduate Studies, Imperial College London

So, what to do when a pandemic makes fieldwork impossible? For Sutton, the answer was to create 3D models of fieldwork sites and features in a virtual game-like environment, bringing the outside world to his homebound students.

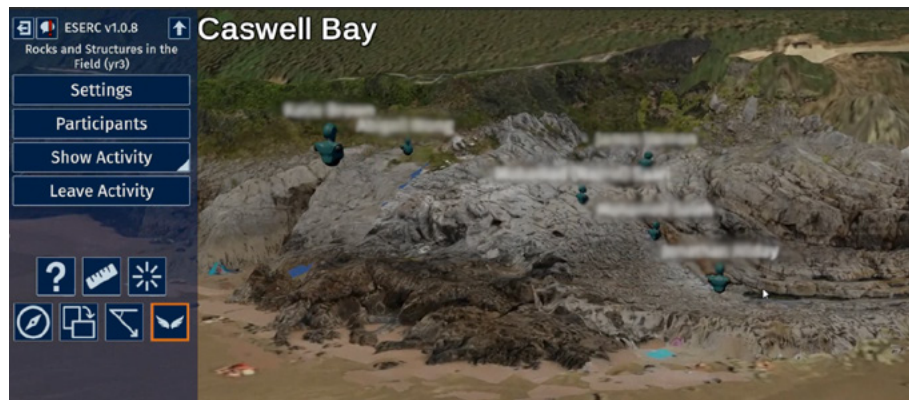


Dr. Sutton demonstrating field techniques to Imperial Undergraduates [Dorset UK]

# Discovering new old life forms with 3D technology

A self-taught programmer with a background in paleontology and geology, Sutton works on 3D reconstructions of worms and other organisms from 400 million to 500 million years ago. “Occasionally, through flukes of preservation, you get the soft tissue preserved as well as the hard bones and shells,” he says. “We have to build 3D models on computers through complicated techniques to actually render them in 3D and to interact with them.”

These models can have important implications for scientific communities. “Because these things are so rare, we tend to discover major, unknown branches of life that we just didn’t know existed.” Sutton says they have changed ideas about certain mollusks, arthropods, early horseshoe crabs, and other forms of life.



Virtual ESERC fieldtrip to South Wales; students examining fold and fault structures in Caswell Bay, Gower Peninsula

Sutton’s excitement is palpable when he describes such discoveries. “No one’s ever seen this particular organism before,” he says. “We don’t know what it is or how it works. We have to puzzle it all out from the information we’ve got. It’s great fun for us, but it’s all science.”

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## Prehistoric options

**Before COVID-19 changed the world, many institutions were already using virtual technology to expose students to remote regions.** “You take some video and combine that with a couple of static images and some Google Earth work,” Sutton says of the virtual trips. “You use those sorts of resources and some photos taken in the field to try to study what’s there. It’s a lot better than nothing, but it’s also a very long way from real field experience.”

When the pandemic caused field trips to be canceled in the spring

of 2020, Sutton’s teams also relied on technology to create virtual experiences. Dissatisfied with the makeshift fix, Sutton drew on his 3D modeling experience to conceive a more ambitious solution.

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Camera drone seeking rock outcrop

# First version of the vision

**Sutton brainstormed with Dr. Matthew Genge, a colleague who is a fellow scientist and amateur programmer.** “Immediately we knew the way to do this is with 3D models in a game-like environment,” Sutton says. “The way in which you get 3D models for these sorts of things involves flying drones over the outcrop, taking large numbers of photos, and passing that to 3D reconstruction software that can take all of those individual images using a technique called photogrammetry and turn them into 3D mesh models, the sort of things you can drop into a game engine.”

Using drone footage and data from a previous trip to Sardinia, Genge and Sutton created a custom Unity solution. Students downloaded the software and were able to experience the Mediterranean in a new way. However, Sutton and his

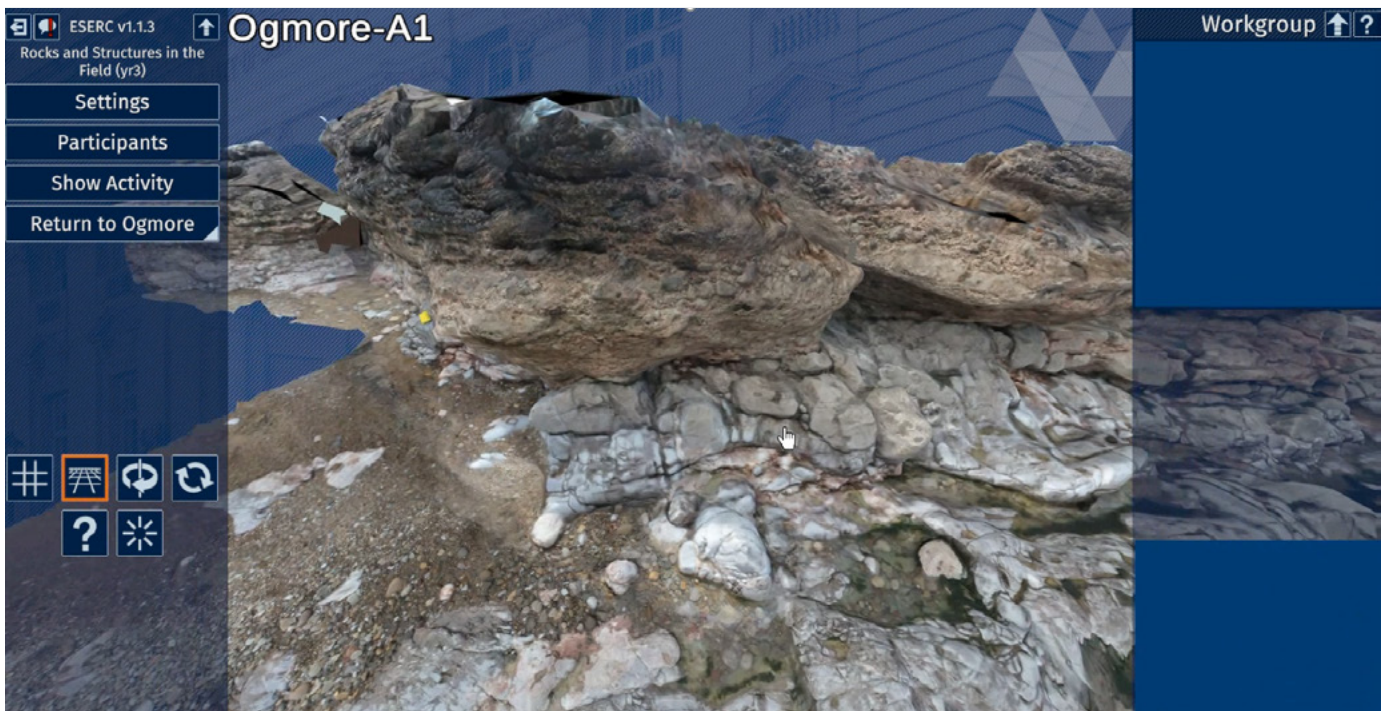
partner wanted to take the premise even further. “It was very much a single-person environment,” Sutton says of the software’s initial iteration. “In real fieldwork, it’s very collaborative. Students go and look at the rocks, but the staff are wandering around and talking to you. You’re talking to your friends. You’re discussing what you’re seeing, and that’s where a lot of the learning actually comes from.”

Sutton and Genge built a flying robot teaching assistant and integrated her into the software. “You could ask predefined questions and get some predefined answers. She was great fun but wasn’t really a substitute for actually having someone there,” Sutton says. With this version as a proof of concept, the pair received funding to execute their vision. However, they knew that to realize their idea’s full potential,

they would need expert help. Sutton found Toptal while doing online research. “I like the general concept of these vetted people who generate high-quality results, which of course they were,” he says about the Toptal business model.

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– Mark Sutton



Detailed ESERC 3D model of an outcrop at Ogmore-by-Sea, South Wales

# Creating “Team Unity”

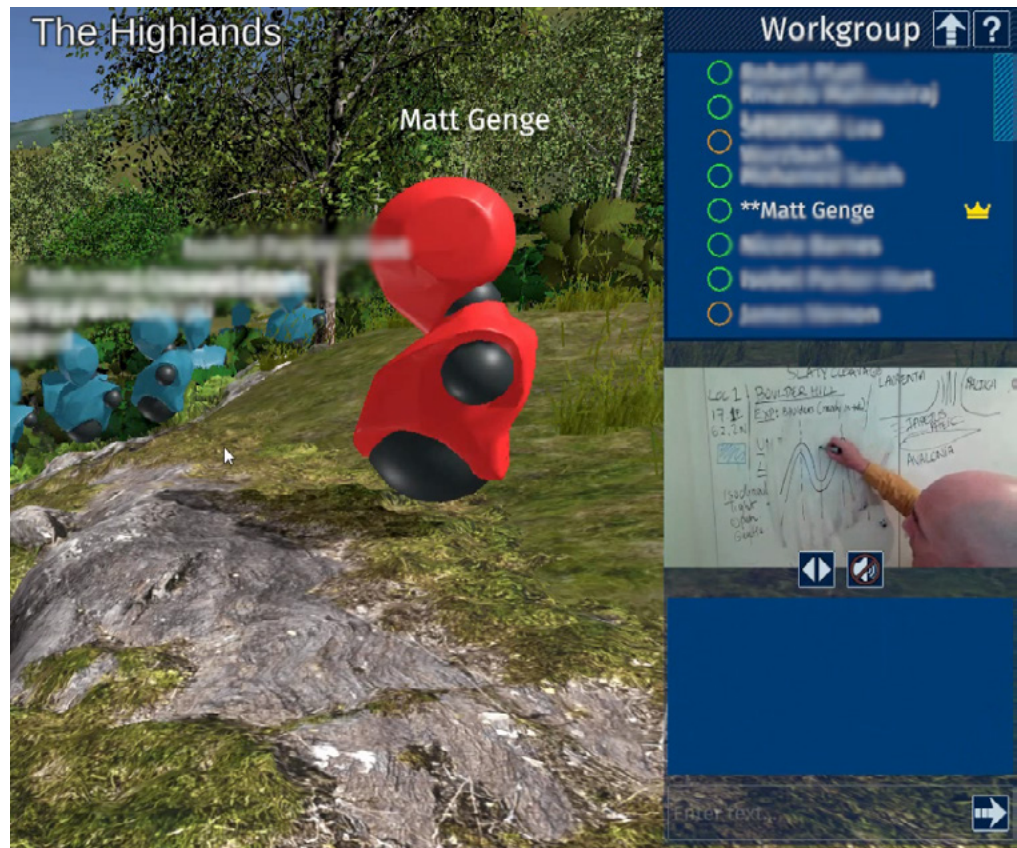
Although the duo had mapped out a central code base and a basic idea of how the software would work, they knew it would require a lot of legwork to deliver a polished product before the start of the upcoming semester. As a result, Sutton took on the responsibility of day-to-day communication with the Toptal team.

Goran Lalić, a highly skilled Toptal developer and experienced game architect, jumped right in. He analyzed the existing code and prioritized tasks to meet the demanding deadline. In three months he refactored the existing code, adapting existing functionalities to fit the new architecture and rewriting those that were unsalvageable. He also integrated Agora middleware to enable video and voice communications. Finally, he created the “fieldwork” functionality, which entailed runtime downloading and execution of large Unity levels, assets, and even executable code.

“This project was awesome,” Lalić says. “It was only because of Dr. Sutton. He is so good. And basically we clicked immediately.

**“When there were deadlines, we got together and put all efforts in the same direction to get everything done. I think our concepts of how things should work quickly aligned properly together.”**

– Mark Sutton



Dr. Matt Genge explaining an outcrop of metamorphic rock on a virtual fieldtrip in Kinlochleven, Scotland

I think that he’s generally a great guy, but he’s also a developer. So, the foundation was already there.”

Sutton agrees. “We meshed really well,” he says. “When there were deadlines, we got together and put all efforts in the same direction to get everything done. I think our concepts of how things should work quickly aligned properly together.”

Lalić and Sutton enjoyed collaborating as well. “We just kept talking, kept working on it, suggesting things, moving backwards and forwards, constantly reevaluating what

we could get in time, what we can’t do, moving things off the urgent list to the less urgent list,” says Sutton. “As a result, it was really fun, and we got through it. We got what we needed done in time.” When asked about his working relationship with Dr. Sutton, Lalić responds: “I don’t know what to say without sounding like I’m being paid by the guy! Very smart. Smart, creative, not the old-school stuffy professor. He’s more like that modern hacker type. So that’s who I got to work with. Come on. Who wouldn’t take that job?”

## Launch time

**Having completed the most urgent work, the team invested time in improving the user interface.** “The UI redesign was not necessary, but we decided to bite the bullet and dedicate time to it,” Lalić says. “In retrospect, it was a very good decision. It helped a lot that I had some experience with web front end, CSS, design, which gave me sufficient understanding to perform the UI redesign myself.”

The investment was worthwhile. “The end result was not only better to look at, but it was also more secure, and the code was cleaner and better integrated with the business logic,” explains Lalić. “I took the design cues, color palettes, and logos from existing Imperial branding and integrated them into the app, which had previously had a custom color scheme.”

They reintroduced the software with its fresh look in time for the

new semester. “It was a resounding success with the students and the staff,” says Lalić. “The software did exactly what it was supposed to do: It enabled the staff to create interactive field trips and exhibits and facilitated remote learning in a Zoom-like environment but with the possibility of having virtual avatars in virtual locations.”

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Developer, Toptal

Sutton was delighted with the upgraded program. “We had 200 or 300 students online in parallel at the same time at points,” he says. “It was being heavily used, and we had very few real problems. Everything



Goran Lalić, Toptal Developer, Toptaler since 2016

was very smooth. We never had to miss a session because it wasn't working. In the end, we were able to deliver all the teaching we wanted to in a better way, as far as I'm aware, than any other Earth Science department anywhere in the world was able to during the pandemic.”

## The sky's the limit

**Even after field trips resume, Sutton plans to continue using and improving the software.** Lalić has continued to work on new features, including a whiteboard feature, new server API code, and virtual reality.

Sutton's team plans to integrate the virtual system into the existing curriculum. “There are huge advantages,” he points out. “If you put a real field trip on, it takes ages to get them to the rock. There are lots of logistics. It's expensive. You can't do it all that often. There are some places you can't go. While

we can take everyone to the coast of the UK, we can't take them all to an erupting volcano in Iceland. We can't take them all to places where the rock outcrop is too small to fit 50 students on it, or the place is on restricted land - or to Mars or the moon. But we have 3D model data for all those places, and can take a virtual trip there.”

Sutton says partnering with Toptal to execute his vision was easy. He adds that the experience was “not overly corporate, which is a slight concern I had in engaging with

consultants. I didn't want to work in an overly corporate environment, and Toptal has been great and flexible. You've all been happy, helpful, and easy to deal with. A breath of fresh air.”

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