Monash Rocks: The first step in an augmented reality journey through deep time

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This paper describes the development of the “Monash Rocks” app - designed to bring our landscape to life through augmented reality. We describe the highs and lows of the development process, the lessons we learned along the way, and our plans for further development of the app to showcase the Monash Earth Sciences Garden and extend the space into further innovative, immersive teaching and learning experiences.

The creation of Monash University’s Earth Sciences Garden (MESG), a "living" geological map of Victoria collating nearly 500 rock specimens, gave us the perfect vehicle for an Augmented Reality (AR) experience. Students and visitors to the MESG can now use the *Monash Rocks* App on their phones to view a 3D display that overlays the live camera feed on the device enhancing the experience of the environment, taking it to another dimension.

The value in augmenting a learning environment is in its ability to pull virtual objects into real scenes (Green & Chandler, 2014, p.549), in this case expanding the physical environment through time and space on a journey back millions of years. The rock now becomes alive, telling its story and supplying information that is missing in the “real life” walk through the garden.

Background

The Monash Earth Sciences Garden (MESG), opened in October 2015, represents the most complex “rock garden” in the world. The MESG is composed of 20 different igneous, sedimentary and metamorphic rocks and its design reflects the spatial locations of the geology of Victoria. The rocks are set out to form a unique geologic map that our students use to learn basic field mapping and rock identification skills before commencing fieldwork.

We envisioned the creation of an Augmented Reality (AR) experience to immerse our students and visitors back millions of years; back through sea beds brimming with now-extinct fish, back to the time of volcanoes to watch lava flow and cool, and back to chase Victoria’s prehistoric fauna between fossiliferous rocks. The value that is added through this technological innovation deepens the understanding of the relationship between the formation of the Earth and our place in its ever-evolving environment. It places the learner in a context of deep time and accentuates our role in the future of our planet.

The pedagogic value of designing a virtual environment facilitates independent learning in an experiential context that is recognised for its motivational value and ability to develop high-level cognitive skills of exploration, analysis, interpretation and reflection. We planned to seize this opportunity by embracing the propensity of our students to use mobile technology, while applying contextual, situated, and authentic learning principles to Monash’s newest learning space.

The affordances of mobile devices make it possible to create learning resources that can respond to markers or geospatial information to enhance each user's experience, taking it to another dimension. The value in augmenting a learning environment is in its ability to pull virtual objects into real scenes (Green & Chandler, 2014, p. 549), providing information that expands the physical environment back through time and space. The augmented MESG now becomes able to tell its story and supply information that is missing in the "real life" walk through the garden. This enhanced experience deepens the perspective of the learner and this extra-sensory interaction consolidates the learning, making it memorable.

The initial project proposal was to build a full App to act as a guide for the MESG, incorporating one complete environmental reconstruction of the Devonian seafloor 410 million years ago. Through consultation with experts in the field of Earth, Atmosphere and Environment (EAE), leading palaeontology and palaeoecology reconstructive artists, and experts in the field of Augmented Reality and 3D animation (SensiLab), the original environment of the rocks formed during the Devonian period were designed and brought to life as an immersive experience.

We received funding from the Monash University - Office of Learning and Teaching (formerly Office of the Vice-Provost Learning and Teaching) to conduct a discovery stage and complete a proof of concept (Phase 1) to demonstrate the capabilities and relevance of the app for teaching and learning.

Phase 1 includes:

- A complete experience for one rock type: The App developed in beta for Apple and Google Play devices - a fully interactive experience that acts as a template for the further development of each rock type
- Videos, graphics, settings, and educational fact sheets with a take home AR artefact
- A suite of learning materials and a website to support pre-visit and post-visit learning for visitors
- Storyboards, graphics, 3D animation proofs, icons, wireframes
- A content database that can be updated and applied to any software interfaces that are developed in the future.

Now that the ground-work is complete, the next stage is the development of AR and immersive environments for a further five rock types and their environs:

- Volcanic lava flows of the Newer Volcanics Province, western Victoria (intraplate volcanism)
- Victoria's Cretaceous dinosaurs and forests
- The eruption of Mount Dandenong
- The formation of Victoria's goldfields
- The formation of the Great Dividing Range.

As the Monash Rocks App has now been constructed, further stages only require 3D modelling, animation, and insertion into the existing App framework. We also now have a very clear idea of the pitfalls to avoid, and where to best invest our energy. We are currently in discussion with interested parties to establish funding for Phase 2.

Monash Earth Sciences Garden - the inspiration

There are seven igneous rocks (lava, scoria and bombs), eight sedimentary rocks (sandstones, limestones and a conglomerate), and six metamorphic rocks (slate, schist, hornfels, migmatite, quartzite and quartz) in the MESG. The rocks have been extensively geo-located using GPS so that when the onsite version of the app is used, it locates the user and highlights the nearby rocks. When each rock is selected, the user is given information that includes when it was formed and information about the position of Australia during that time; detailed information about its formation; and finally, its uses in building and manufacturing. Icons at the foot of the Rock Info page direct the learner to a Gallery of images and web-links for further information. Care has been taken to ensure that each rock has been assigned a colour according to the seamless geological map of Victoria (Department of Primary Industries). External links from the App connect to the Australian Stratigraphic Units Database (Geoscience Australia), and further information about the processes that formed each rock. Gallery images are of the rock as it appears in the MESG, in its natural location, and as used in buildings where appropriate. Information was obtained from published papers and government websites and rewritten for a more general audience. In the case of the Buchan Limestone, the user can also access the icon pointing to details of the fossils associated with the rock and the icon that launches the AR experience. The phone accesses the AR through a VuMark, a type of QR code.

Augmented Reality - bringing it alive

Selection of relevant species groups from fossil record

The function of Augmented Reality (AR) elements within the app is to provide a tangible example of the relationship between the fossil record contained in the rock garden, and the extinct Devonian animals and ecosystem these represent. The Devonian seafloor was selected as our exploratory test case for two primary reasons. The first was that convincing 3D animation is a lot easier to achieve with swimming and floating creatures than with walking, terrestrial ones. The second reason was to explore the visual analogy of 'immersion' in an underwater space, where the viewer is essentially suspended in virtual space where movement, physics and even sound are conveyed differently.

After a thorough literature review of the known and inferred Devonian fossil record of the Buchan area, we selected the following dominant animal groups for the inclusion into the app: armoured fish, cephalopods, crinoids, solitary corals and trilobites. These groups represent all contemporaneous ecological niches: armoured fish and cephalopods are free-swimming (pelagic) or bottom-dwelling (benthic) hunters and foragers, crinoids and corals are sessile filtration feeders, and trilobites are ground-moving scavengers. From these groups, we selected several representative species or animal groups.

Fossil record curation, digital reconstruction and 3D animation

In a combination of scientific and artistic work, we rebuilt selected animals as digital representations. Model construction began with an exhaustive review of published fossil images from scientific publications and museum collections. In some cases, CT-scans of fossils or full fossil reconstructions were available (e.g. Béchard et al., 2014). To guarantee a faithful reconstruction process the creative work was guided and supervised by team palaeontologists and biologists. Natural history artist and palaeontologist Dr Peter Trusler reviewed the collected resources and the creative process and provided feedback.

A team of modellers used the curated images to create three-dimensional models in the modelling software Maya™. Each creature model went through several iterations of feedback, with each stage further refining the shape and detail. Based on movement studies of living relatives (or where available, fossil-based animations, e.g. Anderson & Westneat, 2009), we designed an animation profile for each animal. Behaviour was inferred from known traits of represented individuals (cf. Benton, 2010, Trusler et al. 2011, for an overview of general principles).

Introductory, intermediate and closing scenes

The AR scene can be triggered in two different ways: either by pointing the device camera at a visual marker, or by starting it manually from the app menu. In the former case, an animation displayed over the visual marker shows the assembly of a crinoid from fossil components in the target rock, fading into view from the rock exhibit (Figure 1a). Via a trigger button, the view was replaced by the underwater scene (Figure 1b). In absence of a visual marker (e.g., if the app is used outside the rock garden), a manual start immediately leads to the same scene.

Once the Devonian seafloor fades into view, the user is able to make out the colourful forms of corals, crinoids, trilobites, and groups of fish and cephalopods swimming overhead. Mobile individuals following their behavioural program meander through the water column, while sessile animals gently wave their arms in search for floating food. Figure 1b gives an impression of the underwater scenery.

When the user selects (via another trigger button) to conclude the AR experience, we display an animation of an incoming turbidity current sediment influx. This represents a known method of fossilisation at Buchan, where organisms are rapidly buried following a catastrophic surface or submarine event (Gray et al. 1998). After the cloud has settled a barren seafloor remains, in which all life has been buried by a thick layer of sediment.

User information for each animal

When accessing the Buchan Limestone AR environment, the user is able to click on an animal and obtain more information. This data is laid out similarly to the information in the rock guide and the user is given information, images and web links. Each section begins with a map showing the position of Australia when the animal began to evolve, followed by a description of each animal, its diet, and lifestyle. Reference images show some of the diversity of fossils of each organism, and the user is pointed to websites such as Museum Victoria and similar sites should they wish to access more information.

Teaching worksheets with take-home AR

AR Worksheets have been created for primary and secondary school students (Years 5-6, 7-9, 10-12). These are composed of questions suitable for each year level based around either the Dunkleosteus, crinoid, or ammonoid specimens. Each worksheet has an AR marker that students use to access a 3D augmented reality model of the creature (Figure 1c), allowing them to examine it in detail and sketch it. Answers to the questions can be found either in the Monash Rocks app or through the linked websites. Suggested answers for teachers are also available. Again, information was obtained from published papers and websites and rewritten to make it suitable for a more general audience.

Conclusion

This project aims to bring a new dimension to learning and teaching at Monash. It showcases a unique learning environment and demonstrates the possibilities to faculty members across the University. A key outcome will be the development of templates and protocols for development of similar resources in faculties other than Science.

The nature of this project and its direct application to teaching and learning is in accordance with Monash University's Better Teaching Better Learning Agenda that aims to enhance Monash's learning and teaching reputation through the designing of innovative, learner-centred resources across all faculties.

Our Augmented Reality artefacts situate the learning about deep time in a present-day context. Learners are able to see 3D fossils come to life and watch them moving as they hover over the authentic background of the rock in which they are buried. This visualisation highlights the similarities between these long-gone creatures and their modern iterations enabling the learner to develop a deep understanding of how our environment was formed.

This is not really the conclusion but the beginning of a transformative learning experience that harnesses the use of innovative technology to bridge the gap between reality and virtuality, and brings an immediacy to the learning environment.

References

Anderson, P. & Westneat, M.W. (2009). A biomechanical model of feeding kinematics for Dunkleosteus terrelli (Arthrodira, Placodermi). *Paleobiology*, 35, 251–269.

Béchard, I., Arsenault, F., Cloutier, R. & Kerr, J. (2014). The Devonian placoderm fish Bothriolepis canadensis revisited with three-dimensional digital imagery. *Palaeontol Electron*, 17, 1–19.

Benton M.J. (2010). Studying function and behavior in the fossil record. *PLoS Biology*, 8, e1000321.

Gray, D.R., Foster, D.A., Gray, C., Cull, J. & Gibson, G. (1998). Lithospheric structure of the southeast Australian Lachlan Orogen along the Victorian global geoscience transect. *International Geology Review,* 40, 1088–1117.

Green, D. and Chandler, T. (2014). Virtual ecologies and environments. In M. Grimshaw (Ed.), *The Oxford Handbook of Virtuality* (pp. 549-568). New York, NY: Oxford University Press.

Trusler, P., Vickers-Rich, P. & Rich, T.H. (2011). Where art and science meet. *American Scientist*, 99, 410–411.

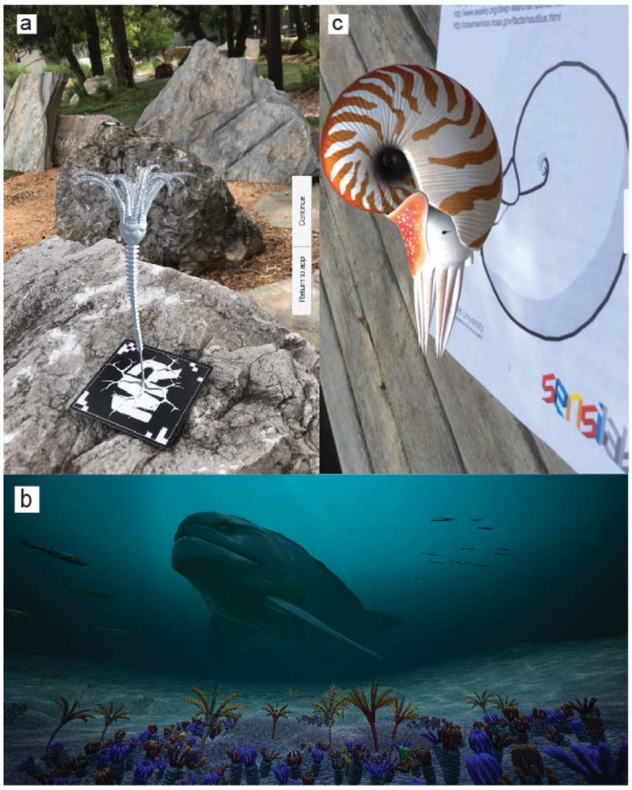

Figure 1: a) Crinoid AR marker in action on the Buchan Limestone,
b) Nautiloid AR marker on a worksheet
c) Screenshot of the Devonian sea floor animation

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