Preliminary Usability Study of an Augmented Reality Sand-Based 3D Terrain Interface

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Augmented reality (AR) sandtables (Ratti et al. 2004) are by their nature a visually-rich tool with great potential to contribute to efficacy of teaching and enriching student learning experiences. The AR sandtable comprises a frame that houses a box filled with sand. Overhanging the box is an arm to which a Microsoft Kinect 3D camera and a digital projector are attached. The Kinect measures the distance from the camera to the sand surface, using its depth sensor and sends this information to a computer at a rate of 30 updates per second. The computer constructs and renders a topographic surface and feeds this to the projector, which displays it onto the surface of the sand in the sandtable. This whole process takes place in near-real-time such that changes in the topographic surface due to the re-arrangement of sand only lag the physical changes by a fraction of a second.

Up to now, the goals of AR sandtable projects have been generally to implement the technology (which has matured and become stable over the years) to build a tool to enhance teaching outcomes in the areas of earth science and computer visualization. For example, the aim of a recent implementation at UC Davis (UC Davis 2016) was to physically create topographic models that can be used as backgrounds for simulations. At UC Berkeley, an AR sandtable has been used in a structured programme to teach principles of terrain, contours, hydrology and geomorphology (Reed et al. 2014). Other installations seem mainly to be located in schools and museums, appearing generally to be presented as a technological marvel

However, there has been no formal analysis of its efficacy in enhancing this teaching activity and improving learning outcomes in a research-led environment, with its specific learning objectives. The original implementation at MIT (Ratti et al. 2004) described the implementation and user experience aspects of an AR sandtable but offers no formal evaluation in an educational setting.

The Otago AR Sandbox has been built using the hardware as previously mentioned and open source software (UC Davis 2016). It was built specifically to teach terrain / engineering principles (earthwork volume estimation) and the spatial analytical (e.g. hydrological modelling) / 3D functionality associated with these domains. This paper presents initial results of a usability experiment and learning observation on the AR Sandbox in a tertiary teaching setting. Terrain, contour and hydrological tasks were performed on Sandbox terrain in both the Sandbox environment and a non-tangible 3D
environment in a GIS (ArcGIS ArcScene with exported Sandbox terrains) and were assessed for efficiency and effectiveness. One of the existing modules in the Introduction to GIS paper at Otago was replaced by a new module to enable this, with students arranged in groups of 2-4. Having completed tests under both conditions (all the while being observed for learning strategies used), knowledge tests and satisfaction usability tests were completed via an online learning module.

Initial results indicate that the student learning experience with both Sandbox and 3D GIS seems the same. However, students indicate more satisfaction (including enjoyment) and performed terrain and hydrological tasks more efficiently with the Sandbox. Finally, the Sandbox fosters the integration of core concepts (especially morphometry) into student learning and predictably encourages more hands-on visualisation of the domain.

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References
