

## Enhancing an instructional design model for virtual reality-based learning

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In order to effectively utilize the capabilities of virtual reality (VR) in supporting the desired learning outcomes, careful consideration in the design of instruction for VR learning is crucial. In line with this concern, previous work proposed an instructional design model that prescribes instructional methods to guide the design of VR-based learning environments. This article provides a thorough elaboration on how formative research is employed to enhance the earlier model. The study has successfully generated five new hypothesized principles to enhance the robustness of the instructional design model through the formative research process. The newly derived hypothesized principles also provide insights into the design of various experimental studies for testing them in the effort to form a more comprehensive guide for the design of VR-based learning environments.

### Introduction

Virtual reality systems can be implemented on affordable personal computers using conventional mouse and keyboard input devices. These systems have lower costs and the potential to be more widely used (Ausburn & Ausburn, 2004; Chuah, Chen & Teh, 2011; Jenson & Forsyth, 2012). Their teaching utility depends on how applications are designed to assist learning (Bakas & Mikropoulos, 2003; Barrett & Blackledge, 2012; Dodd & Antonenko, 2012). Although general instructional design models and theories are useful, more specific ones are needed to exploit the affordances a particular information technology provides (Reigeluth & Frick 1999). Given that it is now possible to display three dimensional graphics and interact with them in real time to replicate real world environments virtually, the question remains as to when providing these environments is needed and how the environments and the ways of interacting with them can be structured to maximize effectiveness.

There are various VR systems ranging from high fidelity, immersive systems to lower fidelity non-immersive ones. This article elaborates an instructional design model originally proposed by Chen, Toh, and Wan (2004), and based on systematic applications of the model to develop and formatively evaluate simulations on a non-immersive VR system. Figure 1 illustrates the model.

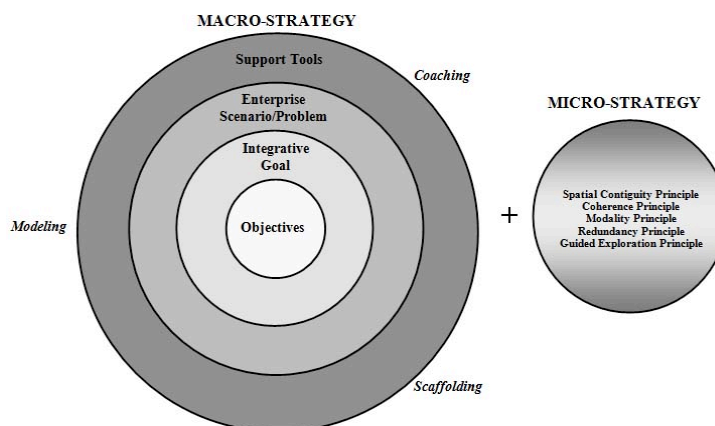


Figure 1. The instructional design model proposed by Chen, Toh, and Wan (2004).

Generally, the model combines the concept of integrative goals (Gagné & Merrill, 1990) with a model for designing constructivist learning environments (Jonassen, 1999). They serve as the macro-strategy, which according to Reigeluth and Merrill (1978), concerns the selection, sequence, and organization of the subject-matter to be presented. Table 1 provides a summary of the principles employed in the macro-strategy. Additionally, a number of design principles, derived from the cognitive theory of multimedia