# Chapter 14
# Virtual Reality Simulations in Science Education:
## Learning Science by Writing

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## ABSTRACT

*This study examines the role of virtual reality (VR) in the promotion of writing with greater complexity and lexical density. Using a combination of neuroimaging and traditional measures, the author characterizes differences in writing complexity and lexical density scores across four different pedagogical modalities: VR alone, VR followed by a textbook reading, textbook reading followed by VR, and textbook reading alone. Middle school students recruited from a rural middle school in the Mid-Atlantic Region of the United States responded to two prompts related to science content found in VR environments and a textbook. The authors hypothesized that exposure to a virtual environment prior to responding to the writing prompts would enhance both argumentative and summative writing products, when compared to participants who only had access to the textbook experiences. Participants who were exposed to the VR environment then had access to a textbook demonstrated significantly greater writing complexity and lexical density scores than those who had VR alone, or access to the text alone.*

## INTRODUCTION

Science education research has sought to understand and develop pedagogical approaches with supports that facilitate 21st Century skills such as critical thinking and written communication related to science (Chu et al., 2017). Of the myriad of options available to educators in the classroom, one of approaches that has been consistently in use in science education is the use of laboratories or activities illustrating specific learning points. However, with the specific illustration of a point there are limitations to the use of laboratories. The limitations arise particularly when the laboratories and activities do not allow individual student exploration or variations in the laboratory outcomes. Activities and laboratories without

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exploration or variations in outcomes are considered rote hands-on activities. Researchers in fields such as neuroscience and learning sciences, have argued that it is necessary to focus less on rote laboratory outcomes and more on the creation of variable outcome experiences which then must be communicated and argued. The variability in outcomes allows students to collect evidence to substantiate claims. The writing to learn aspect occurs as students develop written arguments and analyze claims and evidence to construct scientific understanding and explanation. (Berland & Reiser, 2009; Abersek, 2017). Writing to learn promotes learning through student engagement with authentic contexts and the subsequent explanation of observed phenomena using precise disciplinary language and critique of ideas (Chen et al., 2013). Explanations through writing engage several cognitive systems related to long-term memory, working memory, subordinate functions within working memory such as critical thinking, and other superordinate cognitive systems such as executive function (Leinonen, Keune, Veermans, & Toikkanen, 2016). In short, writing to learn places written scientific communications in the role of a tool to facilitate learning of content within authentic contexts. With the apparent importance of writing to learn in science, the authors of this study are interest in understanding the relationship between aspects of modal presentation and the promotion of writing and critical thinking (Murphy, Rowe, Ramani, & Silverman, 2014).

Developing the practices of 21st Century Skills in written communication in science is a topic of intense research in science education, and adjacent fields such as literacy education, neuroscience, and cognitive science (Baram-Tsabari & Osborne, 2015). However, despite the decades of research on writing to learn in general and in science specifically, differing views regarding writing to learning arise from contrasting approaches of the role of writing. One paradigm suggests writing is a procedural activity (single channel cognitive process) which simply organizes existing knowledge and thinking without the production of new information (Hayes & Flowers, 1986). Other paradigms suggest that writing is an episodic, declarative, and procedural activity (multi-channel cognitive process) in which new knowledge is formulated (Galbraith, 2009). Evidence for each paradigm arises through identification of the cognitive systems which are used during the writing process. For example, evidence of critical thinking and novel information development would suggest the presence of a multi-channel cognitive process. While only the reorganization of existing materials would suggest a single-channel process. Writing to learn under a multi-channel approach suggests that scientific material is best learned via hands-on-experiences, it also is commonly argued that literacy in science derives from having an underlying comprehension of the *language* of science; i.e. the language first approach (Melby-Levag & Lervag, 2014). The *Language First Approach* advocates that writing is used to set up the opportunity to practice communicating (procedural) and explaining content (declarative) in the language of science. However, in developing the language of science it is necessary to activate prior knowledge for the language to interact with. Language first advocates suggest, that writing helps enhance students' conceptual processing and in the analyses of both prior knowledge and new information resulting in novel knowledge development (Chen, Park, & Hand, 2016). The presence of multi-channel processes would be an important consideration in science education contexts and would suggest that the greater the exposure to more authentic experiences would help to produce novel knowledge and promote deeper learning. Through the interactions of cognitive systems in working memory, language, science content, and prior knowledge it is possible to develop scientific language to describe observations of the world. Using scientific language to communicate through writing, students are more likely to engage in deep, meaningful, critical thinking, which results in learning (Townsend, 2015).

While there are many forms of writing the two dominant modes in science are argumentative writing i.e. writing to convince and summative writing i.e. writing to convey information. Current research in