Chapter 5
Using Video Games to Improve Spatial Skills

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ABSTRACT

In this chapter, we explore why and how to use video games for educational purpose to enhance spatial skills. We review the history and trends of the educational use of video games, introduce the concept of spatial skills, and present the importance of spatial skills in STEM education. We outline existing research on spatial training using video games, discuss the methodological issues in these research, and summarize speculated underlying mechanisms of spatial learning. We also discuss considerations in designing video games to maximize the training outcomes of improving spatial skills. We hope that this chapter will not only provide a comprehensive overview of our current knowledge on the importance of learning spatial skills and the potential of video games in facilitating the learning, but also inform about the effective design of video games to accelerate the acquisition of spatial skills.

INTRODUCTION

Spatial skills are a set of skills that allow an individual to create, maintain, and manipulate a visual object in mind, which are distinct from verbal and reasoning abilities. Superior spatial skills have enabled many pioneers in science and engineering to think in spatial images, including Albert Einstein with extraordinary accomplishments in physical science, James Watson who co-discovered the structure of DNA, and Nikola Tesla, the inventor of the basis for alternating current power systems. Spatial skills are central to the success in science, technology, engineering, and mathematics (STEM) disciplines (Sorby, 2001; Stieff, 2011; Kozhevnikov et al., 2007; Wai, Lubinski, & Benbow, 2009). For example, a chemist often visualizes three-dimensional diagrams of chemical molecules; a mechanical engineer may design an automobile engine containing many parts being precisely fitted in space; a radiologist reading MRI images has to be able to recognize the anterior and posterior regions of particular brain structures; a
mathematician may work on solving a geometric problem. Success in any of these activities is highly dependent on superior spatial skills. Much research evidence suggests that training spatial skills can benefit students’ educational outcomes in the STEM disciplines (Miller & Halpern, 2013; Small & Morton, 1983; Uttal et al., 2013a).

Video game is a popular form of media that is widely used in various learning and educational settings. In this chapter, we explore the use of video games for educational purpose to enhance spatial skills. The objectives of this chapter is 1) to introduce the concept of spatial skills and the importance of spatial skills in STEM education, 2) to explore how video games can enhance spatial skills, and 3) to highlight the design considerations of video games for the acquisition of spatial skills.

In the first section, we briefly introduce the history of the use of video games for educational and cognitive training purposes. Nowadays, the value of video games is not limited to entertainment. There is an increasing recognition of video games for their value as educational tools or a training technology in various fields including military, educational institutions, and industry (e.g., Dodlinger & Student, 2007; Egenfeldt-Nielsen, 2007; Girard, Ecalle, & Magnan, 2013; Steinkuehler, Squire, & Barab, 2012). In this section, we discuss the findings of educational and cognitive benefits from playing certain video games.

In the second section, we define spatial skills and discuss why we should take a keen interest in spatial skills. Spatial skill is one of the essential skills for everyday task performance and it has been suggested that spatial skills are a distinct type of cognitive function that is different from verbal function. We address how spatial skills are associated with other fundamental cognitive constructs such as working memory. We also discuss previous literatures that found a strong link between spatial skills and education in STEM domains. In this section, we summarize empirical evidence showing the critical role of spatial skills in academic achievements in STEM fields, and address the importance of cultivating spatial skills in education. We also discuss the evidence of large individual differences in spatial skills and malleability of spatial skills.

In the third section, we present findings from existing research investigating whether and how playing certain video games improve spatial skills. Early studies found that playing Tetris improve individuals’ performance on particular spatial tasks. Given the task involved in playing Tetris is very similar to a typical spatial cognition task, the Mental Rotation Test, it was somewhat expected that individuals who practiced on Tetris would improve on the spatial cognition task. More recent research expanded the scope of video games for spatial training by looking at the effectiveness of video games that is not primarily based on atypical spatial cognition task. These recent findings suggest a potentially new method to improve spatial skills, which is by improving the fundamental cognitive abilities that support spatial skills. In addition to presenting these findings about video games for spatial training, in this section, we also discuss important methodological considerations in these video game training research and the speculated mechanisms of learning.

In the last section, we propose some considerations in designing video games for education to improve spatial skills. Although there is a fast growing body of literature on how video games may benefit spatial skills, it is still not well understood what particular aspects of these games cultivate spatial skills. We will review the potentially critical game characteristics, such as player’s perspective, demand on attention and memory processes, design to improve player’s engagement, and to promote other factors such as parental spatial language use to enhance children’s acquisition of spatial skills. Based on recent findings of attention and working memory capabilities as fundamental building blocks of higher-order spatial cognition, we note the importance of providing mental exercises not only in spatial cognition, but also in attention and working memory. It is widely believed that games should be challenging and stimulating