

Chapter 21

What Cognitive Psychology Can Tell Us About Educational Computer Games

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ABSTRACT

Developers of educational computer games often have incomplete knowledge of the cognitive abilities of learners, yet this knowledge can be useful in informing game design. This chapter reviews two important cognitive abilities that underlie learning: working memory and attentional capacity/executive function. From a description of the developmental course of each ability, we derive a set of recommendations for game developers to follow when designing games for learners of different ages. The chapter next reviews the psychology of transfer of training, including two major theories on the issue. The doctrine of identical elements appears to give the better description of how transfer occurs from training environment (the educational computer game) to target environment (real world performance of the learned skill). It is recommended that games embody, as closely as possible, the end behavior they hope to produce, as this will produce maximal transfer. Finally, we review some controversial research demonstrating distant transfer in computer video gaming.

INTRODUCTION

In this chapter we consider the following questions: (1) What is an educational computer game? (2) How can cognitive psychology inform the developers of educational computer games? and (3) What can we expect in the way of transfer from the educational computer gaming environment to other educationally relevant environments? Our conclusion is that even with well developed, cognitively appropriate educational games, designers should be careful about making claims of widespread transfer, as these claims are rarely substantiated.

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BACKGROUND

Although educational computer games are becoming increasingly popular in the K-12 educational system (e.g., Kebritchi, 2010; Maushak, Chen, & Hai, 2001), it can be difficult to characterize exactly what constitutes an educational computer game. At a minimum, the content must be presented on a computer or other sort of digital media. But beyond that, what is necessary? The philosopher Wittgenstein (1953) asked the question “What is the definition of a game?” His conclusion was that there were no necessary and sufficient features of a game. Rather, the members of the category “games” are bound together by the principle of family resemblance. Some games share features with other games (e.g., solitaire and poker both involve the use of cards), which in turn share features with other games (e.g., poker and craps both involve gambling), and so on. The principle of family resemblance derives from the similarity between members of human families: a child may have eyes that are similar to his father, a smile that is similar to his mother, and ears that are similar to his uncle, but there may be no physical feature true of all of them. Likewise, games share features with some other games, but not with all other games. There are no necessary and sufficient conditions for something to be called a game. Therefore, the search for an adequate definition of educational computer games will end in frustration. Instead, we must rely on our common sense to categorize something as an educational computer game.

Although we may not be able to define educational computer games, we can say something about their function. The purpose of educational computer games is to create learning in students: preferably learning that is broadly applicable to many educational contexts. The computer can serve as a motivational device (the game is engaging, thereby encouraging prolonged interaction), as a feedback mechanism (the game tracks student knowledge, and corrects misunderstandings), and as a developer of proficient skill (continued practice should result in fast and fluid responses, with response times governed by a power law [Newell & Rosenbloom, 1981]). But the key to educational computer games is that they should produce learning that extends beyond the gaming context. This is the question of transfer, and we will return to it later in this chapter.

MAIN FOCUS OF THE CHAPTER

The Development of Cognitive Abilities

A number of cognitive abilities are necessary for children to benefit from educational computer games. Games that might be suitable for a 12th grader would not be suitable for a 1st grader. The abilities we will focus on are memory and attention or executive control.

Memory

Early cognitive theories of short-term memory stressed the storage function of memory over its cognitive control functions. Memory was seen as a multistage processing system (e.g., Atkinson & Shiffrin, 1968) that worked in a very linear fashion. Information from the environment was initially registered in a set of sensory stores. These systems held information from the environment in a raw, unprocessed form for very brief periods of time. There was a sensory store for each of the various senses. Information that was attended to was transferred to a short-term store that held small quantities of information for

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