Chapter 25
The Role of Implicit and Explicit Feedback in Learning and the Implications for Distance Education Techniques

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ABSTRACT

In this chapter, the authors review the cognitive scientific state-of-the-art relevant for Distance Education (DE) followed by an overview of how different aspects of Distance Education relate to such cognitive mechanisms. The goal is to list and categorize the cognitive advantages and disadvantages of DE and consider and discuss how cognitive factors can be negotiated in new developments in DE. The authors argue that modern DE provides excellent opportunities to supplement traditional DE by the providing of contingent feedback while meeting the learner's need to stay intrinsically motivated.

INTRODUCTION

In this chapter we will review the cognitive scientific state-of-the-art we consider important for Education in general and for Distance Education (DE) in particular. We start with general cognitive principles of learning. We will first discuss an approach in cognitive science that argues that cognition is bodily embedded, which explains how our cognitive capacities can be aided by (digital) tools. This idea argues that high-end cognitive capacities are always scaffolded by low-end cognitive capacities. In accord, we argue that educational principles are likely scaffolded on the natural pedagogical instincts that exist between parent and infant. We show how both unconscious, seemingly redundant behaviours and purposeful consciously generated behaviours are processed embodied by observers and that this embodiment forms the ground for learning. We learn from the

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unanticipated effects that our and other's actions have. Learning, however, is best fuelled by the intrinsic motivation of the learner, as argued by the Self-Determination Theory (SDT). It is hard to establish the beliefs and self-controlling abilities of learners, however, to which the autonomously motivated learners attribute the outcome. In the second part we relate these aspects to DE in general, how they may fall short, and how they may excel in the cognitive factors. In the last part we will discuss how new technologies can address the cognitive shortcomings of DE. We will argue that modern DE provides excellent opportunities to supplement traditional DE by the providing of contingent feedback while meeting the learners needs to stay intrinsically motivated.

BACKGROUND

'Learning is the residue of thought', as it was concisely concluded by Daniel Willingham (2009). How do we think? What do we think about? We will argue that thinking is essentially bodily embedded. Embodied Embedded Cognition (EEC), or grounded cognition, in short, argues that cognitive functions are scaffolded on basic and available mechanisms that can aid to achieve the organisms goal. High-end human cognitive capacities are grounded by more low-end, fundamental capacities and high-end capacities are often impaired if the low-end capacities are compromised, of which we will show a few relevant examples below. Hence, low-end capacities, in particular motor skills, are crucial to what we think about and how we think, and, consequently, what we learn. Learning always occurs in the context of what is already available.

Following this embodied framework, learning math, for example, is scaffolded on a capacity of general motor abilities that estimate quantities (e.g. Walsh, 2003). We share with many animals, the ability to estimate quantities by the perceptual size, weight, length, which is thought to enable simple functional decisions. Lions are able to estimate the size of an approaching pack and, by comparing this with the number of their own pack, decide to either approach or withdraw. Rats are able to maintain the numbers of eaten items of different categories (e.g. raisins and grains) as well as the total number of eaten items (Capaldi & Miller, 1988). This 'numerosity' (Dehaene, 1999) helps to decide to approach or withdraw from others, to eat or burrow food, even to manipulate such numerosities in some basic calculus to achieve rewards, thus utilizing it for more 'high-end' capacities. Human's ability to symbolically manipulate such numerosities enables them to generate make abstract and rational inferences. Importantly however, this implies that in order to achieve high-end capacity of complicated calculus and, ultimately, advanced math problems, low-end capacities have to be available, as EEC theory predicts. Indeed, when young western children learn to add numbers, they show a slight slowing when the product is more than 5, whereas young eastern children show this slowing when the product is more than 9. This cultural difference is related to finger counting habits. Whereas in western culture counting over 5 requires a second hand, whereas in eastern culture one hand is used to count up to 9. This disposition continues into adult live; illustrating how fundamental finger counting is for calculus. Children with 'finger-agnosia', a disturbed representation of the different fingers which is common in Gerstmann's syndrome, are often bad at math. Children with dyscalculia, who suffer from the inability of performing simple mathematical transformation with numbers, benefit from physical training of the representation of numbers (Butterworth, Varma, & Laurillard, 2011; Fischer, Moeller, Bientzle, Cress, & Nuerk, 2011). Although it is thought to be the most fundamental capacity, EEC does not suggest that motor abilities are the *only* scaffolding low-end capacity by which math may be supported. In the process of learning math, other mechanisms may lower cognitive efforts along

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