



Review article

Pen or keyboard in beginning writing instruction? Some perspectives from embodied cognition



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ABSTRACT

Reading and writing are increasingly digitized at all levels of education, and in beginning writing instruction, children are often introduced to writing by using keyboards rather than by pen-and-paper handwriting. The short-term and long-term cognitive, educational and socio-cultural implications of such a transition are largely unknown. In this article, we discuss some urgent questions relating to the ongoing marginalization of handwriting. By reference to extant research particularly addressing the motor component of writing, and drawing on key theoretical insights of embodied cognition, we address the role of the material affordances and sensorimotor contingencies of keyboards and handwriting implements in the development of basic writing skills.

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1. Introduction

Adequate reading and writing skills are defining components of literacy, and a main goal in education.¹ By definition, writing systems are cultural artefacts that must be learnt through systematic instruction. Whereas oral language is normally easily acquired through mere exposure, there is no genetic blueprint for reading and writing [99]. As Steven Pinker famously described, “Children are wired for sound, but print is an optional accessory

that must be painstakingly bolted on” ([79], pp. ix-x). Literacy must be taught and learnt, and even years of formal training does not guarantee complete mastery of the processes and mechanisms involved.

For a long time, learning to write unequivocally referred to the practice of pen-and-paper manuscript of lowercase and uppercase letters, followed at a later stage by cursive (a k a joined-up, or joint) writing. Today, many children get their first writing experiences by using different kinds of keyboards, and they may or may not be trained in writing by hand using pen and paper (or using tablets and digital stylus). The marginalization and occasional abandonment of handwriting in schools in Europe and the US have fueled heated debates in the media, including an increasing number of popular science publications on the “lost art” of handwriting (e.g., [7,23,28,45,52,57]).

The surge in popular attention to the potential downsides of

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¹ See UNESCO, “Education for All Global Monitoring Report 2006”, Chapter 6, URI: http://www.unesco.org/education/GMR2006/full/chapt6_eng.pdf for a discussion of the term “literacy”.

replacing pens and pencils with keyboards is paralleled by increased scholarly and scientific interest in the vital role of the body and of fine motor skills, e.g., drawing and writing by hand, for cognitive development and learning/literacy outcomes (e.g., reading and writing). This interest is perhaps most clearly expressed, and most systematically implemented, in the interdisciplinary paradigm of embodied cognition. Highlighting the role of bodily movement and motor action for cognitive processing, embodied cognition can be described as a sub-category within the broader framework of grounded cognition (e.g., [9,10]). According to this framework, cognition is understood as being grounded in four ways: (i) in modality-specific systems (e.g., vision, audition, olfactory and gustatory), (ii) in the body and in bodily movements, postures and action, (iii) in the physical environment (a.k.a. situated cognition), and (iv) in the social environment [54].

In this broader framework, embodied cognition implies, specifically, that human cognition is not limited to internal processes within the brain, but that cognitive processing is fundamentally dependent on the body, postures and bodily movement in and engagement with the physical environment in which we live (for an overview, see e.g. [86,98]). Developmental psychologist Esther Thelen and colleagues provide the following explanation:

To say that cognition is embodied means that it arises from bodily interactions with the world. From this point of view, cognition depends on the kinds of experiences that come from having a body with particular perceptual and motor capacities that are inseparably linked and that together form the matrix within which memory, emotion, language, and all other aspects of life are meshed ([92], p. 1).

More specifically, cognition is embodied in that it is “based on reinstatements of external (perception) and internal states (proprioception) as well as bodily actions that produce simulations of previous experiences” (Kiefer and Trumpp, 2012, p. 16). Embodied cognition thus entails a radical departure from understanding cognition as a system of information-/symbol-processing taking place in the brain as a central processing unit [15,16,29], to understanding how human cognition and behavior emerges from the real time interplay of task-specific resources distributed across the brain, body, and environment, coupled together via our perceptual system [96].

Considered in light of certain tenets of the embodied cognition paradigm (cf. more detailed elaboration below), the ongoing replacement of handwriting by keyboard writing in children's beginning literacy instruction may in some respects seem ill advised. However, the increasing influence of embodied cognition could also be exactly what is needed to “give the body its due” [87] in theories of learning, literacy and writing. There is, in educational science research, an increasing awareness of the fundamental role of the body in learning, and experimental paradigms enabling measures of, e.g., body movements in the reduction of cognitive load, are being developed (see for instance [36,37,38]). The shift from writing by hand to writing by keyboard may serve to propel and solidify an understanding of the role of embodiment in learning and cognitive development overall. In her aptly titled book *Embodiment and Education*, Marjorie O'Loughlin claims that education theorists seem to be rather uncomfortable with “the brute fact of corporeality” (2006, p. 6 [76]). She calls for a replacement of the “scopic regime” – the epistemological privileging of vision in western culture and education – with a focus on “the corporeality, emotionality and sociality of human beings and their material processes.” (2006, p. 17) What is meant by “material processes” here is, however, somewhat unclear. Instead, we propose to take the material affordances of writing technologies as a starting point, and discuss some ways in which the ongoing digitization may bring about a better awareness of associations

between material affordances, sensorimotor contingencies, motor input and cognitive outcomes when writing with different technologies.

Fine-motor skills in general are found to be a significant predictor of later academic achievement [25], and the same applies to early sensorimotor (action) experiences [12]. Several studies have shown that handwriting supports visual processing of the graphic shapes of individual letters [48,50,51,75,95], and a recent experiment with preschoolers showed better accuracy for handwriting training than for typewriting training in word-level reading and writing tasks [55].² Automatized letter writing, moreover, has shown to be the best predictor of text length as well as text quality for elementary school children [82]. Such findings, together with emerging knowledge in embodied cognition about the fundamental contribution of sensorimotor processes to higher-level cognition (see [13] for an overview), suggest that a marginalization of handwriting may have considerable implications, socially as well as on an individual level.

The objective of this article is to shed light on some implications of the current transition from writing by hand to writing with keyboard in beginning writing instruction.³ Focusing on writing as skillful handling of writing devices and implements and integrating fine motor skills, visuo-perceptual and cognitive processing, we discuss some potential educational implications of such a transition. Specifically, we focus on the sensorimotor contingencies [77] of writing technologies and the (grapho)motor processes in writing, and discuss some arguably crucial questions pertaining to the changing ergonomics and material affordances brought about by digitization.

2. Writing and technologies: some preliminaries

Whether by hand or by keyboard, writing is a composite skill involving fine-tuned coordination of motor processes, perception and cognition. No single theoretical framework or model can be assumed to account for the processes in their entirety, a fact to which the theoretical pluriformity of writing research is testimony. The question of “pencil or keyboard in beginning writing instruction” does in fact reveal an epistemological schism in writing research, between scientists doing experiment-based research (in psychology and neuroscience), and literacy scholars primarily doing qualitative case studies. A recent review study of research comparing handwriting and keyboard writing in beginning writing instruction [100] found differences in findings and implications along these lines. Wollscheid et al. [100] assessed the emerging literature on digital writing tools (computers and tablets) compared with traditional writing tools (pen/pencil and paper), on early writing outcomes among beginning writers (Grade 1–3). The authors found that research literature fell into three clearly distinct categories: (i) a cognitive psychology perspective; (ii) a neuroscience perspective; and (iii) a sociocultural theoretical perspective. Cognitive-psychological studies (e.g., [18,19]) indicate an overall advantage of pen and paper compared to digital writing tools for early writers on both low- level and high-level writing outcomes. At the same time, some findings seem to favor keyboard writing for automatic letter production, while pen and paper seems advantageous for writing tasks such as essay writing [11]. Studies from neuroscience [50,66] seem overall

² An experiment with adults [69] comparing word recognition and recall across three writing modalities – handwriting; mechanical (laptop) keyboard writing; virtual/touchscreen (iPad) keyboard writing – found that participants had better free recall of words written by hand compared to both keyboard conditions.

³ For examples of beginning writing instruction policy and pedagogy, we refer to the situation in Norway, with which we are most familiar.

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