Journal of Experimental Child Psychology 153 (2017) 110–125

Contents lists available at ScienceDirect

Journal of Experimental Child Psychology

journal homepage: www.elsevier.com/locate/jecp

Going beyond the lesson: Self-generating new factual knowledge in the classroom

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A R T I C L E I N F O

Article history:
Received 15 July 2016
Revised 7 September 2016
Available online 8 October 2016

Keywords:
Knowledge extension
Academic performance
Self-generation
Elementary education
Learning
Integration

A B S T R A C T

For children to build a knowledge base, they must integrate and extend knowledge acquired across separate episodes of new learning. Children's performance was assessed in a task requiring them to self-generate new factual knowledge from the integration of novel facts presented through separate lessons in the classroom. Whether self-generation performance predicted academic outcomes in reading comprehension and mathematics was also examined. The 278 participating children were in kindergarten through Grade 3 (mean age = 7.7 years, range = 5.5–10.3). Children self-generated new factual knowledge through integration in the classroom; age-related increases were observed. Self-generation performance predicted both reading comprehension and mathematics academic outcomes, even when controlling for caregiver education.

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Introduction

A major goal of education is to accumulate a knowledge base. Educators employ many strategies to engage learners in knowledge acquisition, including direct tuition, project-based learning, and tests, to name a few. Importantly, to accumulate knowledge over the educational career, learners must not only learn from individual episodes of experience but also integrate classroom lessons with one another across time and medium. Moreover, to accumulate knowledge quickly and efficiently and thereby foster academic achievement, they also must go beyond what is directly given in learning epi-

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http://dx.doi.org/10.1016/j.jecp.2016.09.003
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sodes to self-generate novel understandings. They also must retain the newly derived knowledge over time. It has been established that under controlled laboratory conditions, children as young as 4 years productively extend their knowledge base through integration of separate lessons of new learning (Bauer & San Souci, 2010). They also remember the new information over a delay (Varga, Stewart, & Bauer, 2016), as do 6-year-olds (Varga & Bauer, 2013). However, the assumptions that children engage in these processes across classroom learning episodes and that the processes contribute to academic performance have not been tested. Accordingly, in the current research, we tested 5- to 9-year-old children's self-generation of new factual knowledge through integration of separate yet related episodes of new learning in the classroom and how performance relates to academic achievement.

Both within and outside the classroom, learners of all ages engage in productive processes such as analogy, deduction, induction, and textual inference (e.g., Gentner, Loewenstein, & Thompson, 2003; Goswami, 1992, 2011; Paris & Upton, 1976; Perret, 2015). Without these productive processes, learning would proceed slowly, as each and every bit of information is acquired individually. For example, in teaching addition, rather than explicate each specific equation individually, teachers instruct that addition is an operation applied to an infinite combination of numbers. Because of the capacity of productive processes to foster rapid and efficient accumulation of knowledge, they are assumed to be a major mechanism of cognitive development (Bauer, 2012; Bauer & Varga, 2016; Brown, 1982; Siegler, 1989).

Consistent with their status as mechanisms of cognitive development, productive processes have been observed even in very young children (e.g., Singer-Freeman & Bauer, 2008; see Goswami, 2011, for a review). For example, infants in the second year of life extend the property "drinks from a cup" to novel animals but not to novel vehicles and extend the property "starts with a key" to novel vehicles but not to novel animals (Mandler & McDonough, 1996). There also are age-related increases in the efficacy of productive processes such that, relative to younger children, older children engage in them more consistently (Goswami, 2011). Developmental changes are attributed in part to increases in general abilities such as working memory and inhibitory control (i.e., the ability to ignore distracters) (Crone et al., 2009; Goswami, 2011).

In addition to increases in general cognitive abilities supporting productive processes, older children have had more experiences contributing to their knowledge base. Productive processes, such as transfer through analogy, are more likely when children understand the underlying concepts (Brown, 1989; Gentner et al., 2003). For example, physics students who already understand how water flows can use that analogy to understand electricity concepts (Gentner & Gentner, 1982). This type of transfer is limited to situations in which there is an appropriate already well-known model that can be accessed and, like other productive processes, is highly dependent on surface similarity, especially in novice learners (Brown, 1989; Gentner, 1989; Gentner et al., 2003).

Encouraging productive self-extension of knowledge is one of the foundations behind "discovery learning" models, in which children are active participants in building their own knowledge base through experience (Mayer, 2004; Sobel & Sommerville, 2010). A meta-analysis on discovery learning showed that unassisted discovery learning (i.e., when children are provided no guidance) does not have an advantage over explicit instruction (Alfieri, Brooks, Aldrich, & Tenenbaum, 2011). However, when discovery learning is guided with feedback and worked examples, children have higher rates of learning (Alfieri et al., 2011).

Importantly, in terms of the question of how a knowledge base accumulates over time, the existing literatures on productive extension of knowledge are not fully informative for three primary reasons. First, in many cases, the material over which the processes are tested is not representative of the factual content of a knowledge base. Instead, it is of arbitrary relations that are not intended to correspond to real-world semantic knowledge. For example, in a study of inductive reasoning, Schulz, Goodman, Tenenbaum, and Jenkins (2008) showed preschool-age children a series of block combinations. Some block combinations emitted a sound (e.g., a train whistle), whereas others were inert. Immediately after the demonstration, children were tested to determine whether they could induce the composition of unseen block combinations based on whether they emitted a sound. The task taps children's understanding of basic causal principles; however, the information used to induce the principles is not expected to add to factual knowledge of blocks, whistles, or trains.

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