Learning and Instruction xxx (2016) 1–10

Contents lists available at ScienceDirect

Learning and Instruction

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

Learning from direct instruction: Best prepared by several self-regulated or guided invention activities?

Inga Glogger-Frey [a, *], Katharina Gaus [a], Alexander Renkl [a]

[a] Department of Psychology, University of Freiburg, Educational and Developmental Psychology, Engelbergerstr. 41, 79085 Freiburg, Germany

ARTICLE INFO

Article history:
Received 15 April 2016
Received in revised form
29 October 2016
Accepted 7 November 2016
Available online xxx

Keywords:
Invention activities
Worked examples
Physics education
Self-regulated preparation for learning
Cognitive load

ABSTRACT

Learning from direct instruction can be enhanced by preparatory invention tasks: students invent an index that allows to differentiate a set of cases regarding important aspects (self-regulated). However, contradictory results have been found. As self-regulated activities often need practice, we tested whether the contradictory findings persist when students can practice inventing. We randomly assigned 99 eighth-grade students to two conditions (independent variable): they either invented twice (self-regulated; $n = 49$) or worked through worked solutions of the two tasks (guided; $n = 50$) before learning about ratios in physics from a lecture. Extraneous load, deep-structure recall, knowledge-gap perception, and self-efficacy were potential mediators. Transfer was the dependent measure. Guidance led to less extraneous load. However, self-regulation led to higher transfer because the students devoted more attention to the deep structure of the preparation tasks. Our findings suggest that—given some practice—self-regulated outperforms guided preparation for learning from direct instruction.

1. Introduction

Direct forms of instruction can lead to favorable learning outcomes (e.g., Kirschner, Sweller, & Clark, 2006). However, direct forms of instruction have also downsides. Many students process the presented information only superficially. Students then have difficulty transferring the acquired knowledge to future transfer tasks (e.g., Dean & Kuhn, 2007). Schwartz and colleagues (e.g., Bransford & Schwartz, 1999; Schwartz & Martin, 2004; Schwartz, Chase, Oppezzo, & Chin, 2011) have proposed one potential solution to this problem. Before receiving direct instruction (e.g., a lecture), the students compare contrasting cases, that is, cases that share many features but differ in important aspects (i.e., deep-structure features) that should stand out. Fig. 1 illustrates such contrasting cases (Schwartz et al., 2011): three bus companies (e.g., "Funny Clowns") can be contrasted regarding their "crowdedness". Each of the three companies has differently sized buses with the same crowdedness, that is, ratio of number of clowns and of compartments, but the ratio differs across companies.

The problem posed to the learners is to *invent* a crowdedness index for the companies (i.e., inventing procedure). The same company always crowds the clowns to the same extent, and students are asked to use the exact same procedure for each company to find its index. Thereby, the learners are prepared for understanding density: they can work out that the number of clowns is an aspect differing between buses (pointing to "mass/content matters"), as well as the number of compartments (pointing to "volume matters"). However, only the relationship between the two variables differentiates the companies reliably. The three features, mass/content, volume, and their relationship, are the deep structure features in this case. On a more general level, Schwartz et al. (2011) assume that such contrasting cases have the potential to sensitize students for ratio structures in physics (cf., e.g., the concept of speed).

There is evidence that such an inventing procedure fosters students' learning from later direct instruction (e.g., Roll, Holmes, Day, & Bonn, 2012; Schwartz & Martin, 2004; Schwartz et al., 2011; Schmidt, De Volder, De Grave, Moust, & Patel, 1989). In their review on strongly and less guided forms of instruction, Lee and Anderson (2013) interpret the positive findings on inventing as showing that it makes sense to combine less guided (i.e., more self-regulated) forms of instruction with later direct instruction in order to exploit their respective advantages (see also Kapur, 2012; for a very similar argument).

* Corresponding author. Department of Psychology, University of Freiburg, Educational and Developmental Psychology, Engelbergerstr. 41, D-79085 Freiburg, Germany.
E-mail addresses: glogger@psychologie.uni-freiburg.de (I. Glogger-Frey), katharina.gaus@web.de (K. Gaus), renkl@psychologie.uni-freiburg.de (A. Renkl).

http://dx.doi.org/10.1016/j.learninstruc.2016.11.002

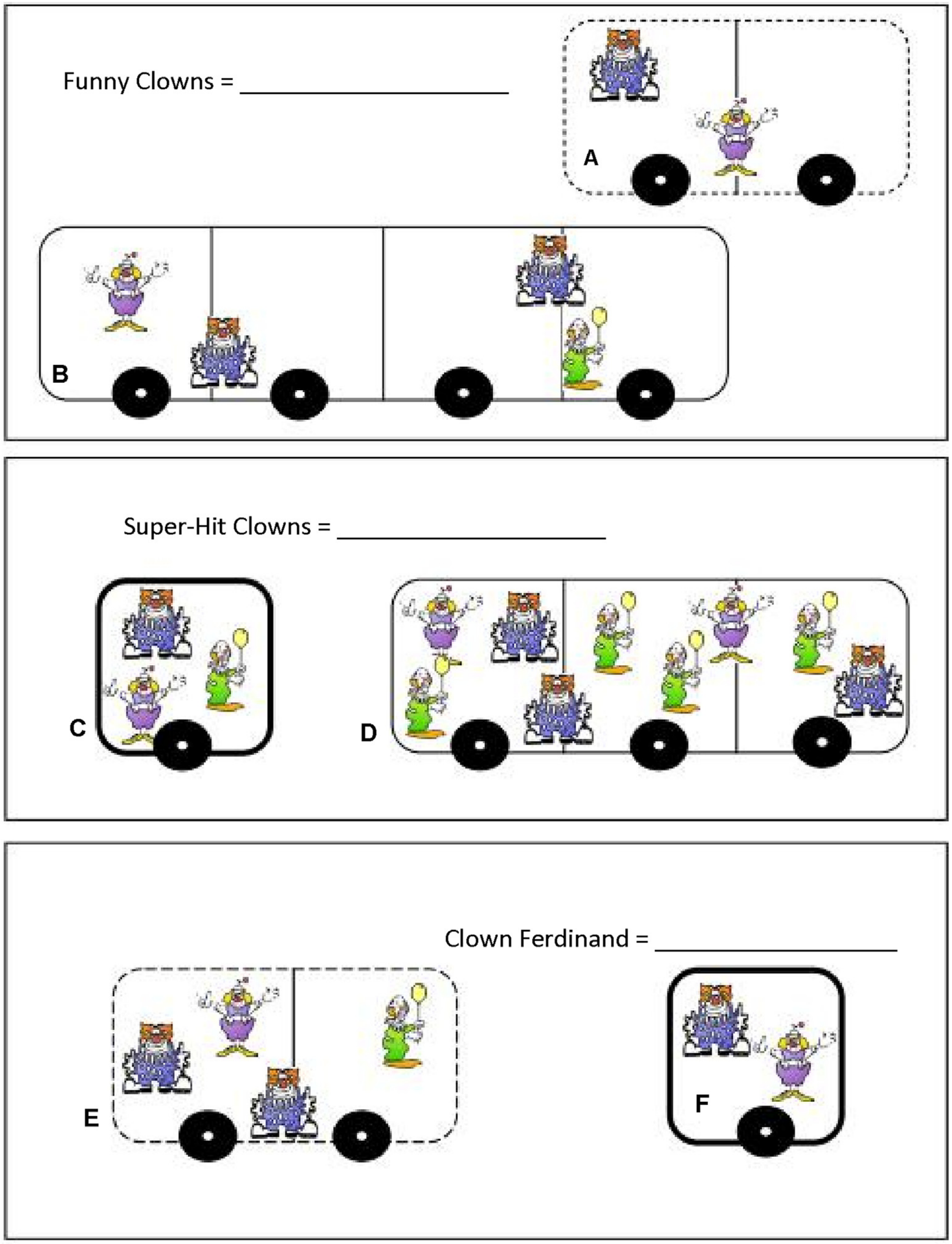

Fig. 1. Contrasting cases: they share many features but differ in deep-structure features, here number of compartments of buses, number of clowns, and the ratio between the two (buses and clowns are taken from Schwartz et al., 2011). These cases were used in the first preparation phase.

However, some researchers (e.g., Sweller, Kirschner, & Clark, 2007) have criticized the inventing studies for having "weak" control conditions. Weak control conditions differ in more than one variable from the experimental condition or that the differing variables are not relevant to the (to-be-tested) issue at hand (e.g., the control condition has less time on learning contents than the experimental condition). In line with this critique, Glogger-Frey, Fleischer, Grüny, Kappich, and Renkl (2015a) found in two prior experiments that providing guidance when analyzing the contrasting cases by worked solutions better prepares further learning from direct instruction than does self-regulated inventing as a preparation activity. In the present study, we tested the robustness of this finding when changing a potentially relevant context condition. The students in Glogger-Frey et al. (2015a) had only one inventing phase, whereas typical invention studies used at least two such phases (e.g., Roll, Aleven, & Koedinger, 2011; Schwartz & Martin, 2004; Schwartz et al., 2011). The students may need to learn how to productively approach such self-regulated inventing tasks before they become effective (Lee & Anderson, 2013). Hence, this study investigated whether worked solutions are still superior even when the students have the opportunity to practice inventing.

1.1. Self-regulated inventing: potentials for preparing further learning

Inventing tasks require that students, usually in pairs or small groups, invent an index to differentiate a set of cases regarding important aspects (e.g., "crowdedness index" to differentiate clown

Please cite this article in press as: Glogger-Frey, I., et al., Learning from direct instruction: Best prepared by several self-regulated or guided invention activities?, *Learning and Instruction* (2016), http://dx.doi.org/10.1016/j.learninstruc.2016.11.002