ELSEVIER

Learning and Instruction 19 (2009) 158–170

Learning and Instruction

www.elsevier.com/locate/learninstruc

The effects of cooperative learning and feedback on e-learning in statistics

Ulrike-Marie Krause [a,*], Robin Stark [a], Heinz Mandl [b]

[a] *Institute of Education, Saarland University, P.O. Box 151150, 66041 Saarbrücken, Germany*
[b] *Department of Psychology, Ludwig Maximilian University, Leopoldstraße 13, 80802 Munich, Germany*

Received 2 August 2007; revised 30 December 2007; accepted 7 March 2008

Abstract

This study examined whether cooperative learning and feedback facilitate situated, example-based e-learning in the field of statistics. The factors "social context" (individual vs. cooperative) and "feedback intervention" (available vs. not available) were varied; participants were 137 university students. Results showed that the feedback intervention clearly supported learning. Feedback proved especially beneficial for students with little prior knowledge. Cooperation did not promote learning outcomes; however, group performance in the learning phase was superior to individual performance. Also, cooperative learning enhanced perceived performance and perceived competence. Probably, collective efficacy had a halo effect on self-efficacy.

Keywords: Cooperative learning; Feedback; E-learning; Statistics education; Worked examples; Perceived performance; Perceived competence

1. Introduction

Many students of social sciences have difficulties understanding and applying statistical concepts and procedures (Broers & Imbos, 2005; Stark & Mandl, 2000). Yet, large numbers of students make individual tutoring difficult. In addition, many students lack motivation concerning mathematical issues, and some suffer from mathematics anxiety (Onwuegbuzie, 2004). Starting from this problem, the e-learning environment *Koralle* (Tyroller, 2005; see also Krause, 2007) on correlation analysis was developed. In the present study, we tested two interventions that were expected to increase effectiveness of the e-learning environment: cooperative learning and feedback. We investigated effects of these interventions on objective and subjective learning outcomes (Stark, Gruber, Renkl, & Mandl, 1998). Concerning objective outcomes, we focussed on students' ability to solve realistic problems. As regards subjective outcomes, we examined perceived performance and perceived competence, which are relevant for students' self-efficacy (Bandura, 1997) and thus for their motivation (Deci & Ryan, 2000; Pajares, 1997). Subjective outcomes are especially important in the field of statistics, where many students lack confidence in their abilities and therefore avoid the subject.

The following section outlines the conception of the learning environment and the theoretical and empirical background of the two additional interventions. Then, the study is described and main findings are discussed.

* Corresponding author. Tel.: +49 681 302 3391; fax: +49 681 302 4708.
E-mail addresses: u.krause@mx.uni-saarland.de (U.-M. Krause), r.stark@mx.uni-saarland.de (R. Stark), heinz.mandl@psy.lmu.de (H. Mandl).

0959-4752/$ - see front matter © 2008 Elsevier Ltd. All rights reserved.
doi:10.1016/j.learninstruc.2008.03.003

1.1. The e-learning environment Koralle

To facilitate learning in statistics a number of instructional interventions have been tried (Lan, 1998; Stark & Mandl, 2000). In this respect, e-learning has gained importance in recent years, as it enables students to learn in a self-regulated manner and is considered to be a way to assist learners individually even under adverse learning conditions (Mandl & Krause, 2003). In the present study, the e-learning environment Koralle on correlation analysis was implemented. Correlation is a central concept in statistics and, at the same time, a topic that consistently creates problems to students.

The e-learning environment was developed for statistics education in social sciences. It is geared towards university students who have already attended introductory statistics courses (and who should possess basic mathematical knowledge). Koralle addresses often neglected descriptive aspects of correlation, such as linearity and effects of outliers on the correlation coefficient. As the e-learning environment is meant to enhance acquisition of applicable knowledge, it was designed according to principles of situated learning (Cognition and Technology Group at Vanderbilt, 1997): subject matter is embedded in a realistic context, and learners have to deal with complex problems that are relevant to students of social sciences (e.g., analyzing data for a thesis).

Koralle is based on worked examples; this approach has repeatedly proved efficient in well-structured fields (Sweller & Cooper, 1985; Van Gog, Paas, & Van Merriënboer, 2006). Worked examples demonstrate problem solving in a step-by-step manner and therefore facilitate acquisition of appropriate solution schemas for structurally similar problems (Sweller & Cooper, 1985). Effectiveness of example-based learning is often explained by cognitive-load theory (Sweller, 1988): studying examples requires hardly any mnemonic search processes, so instruction-based demands on working memory (extraneous load) are low. Capacity can thus be more thoroughly used for productive learning activities (germane load), such as self-explanations (Renkl, 2005).

However, when students are not explicitly activated, they often rather passively read than actively self-explain and mindfully process example information (Stark, Mandl, Gruber, & Renkl, 2002). Therefore, in Koralle worked examples are systematically combined with problem-solving tasks (Stark, Gruber, Renkl, & Mandl, 2000): students first actively solve a problem, and afterwards a worked example is presented that demonstrates the correct solution procedure. Students can compare their own solutions to the example information; the examples, therefore, function as feedback. This approach should be effective when students have prior knowledge that can be activated by problem solving (Krause & Stark, 2006).

In an experimental study, Koralle facilitated knowledge acquisition (Tyroller, 2005). Students who had learned with Koralle scored higher in a test on correlation analysis than their peers who had merely attended a lecture on correlation. However, further analysis of students' answers revealed deficits in their knowledge structure; many answers indicated that even students who had worked with Koralle partly lacked deeper understanding. Especially, participants with little prior knowledge did rather poorly. These results might be due to special properties of e-learning and of learning with worked examples. Unlike learning in the classroom, *e-learning* is generally a solitary process. However, students need communication with others in order to externalize their own ideas, to elaborate the presented information, to get feedback, to identify their own knowledge gaps as well as their misconceptions (see, e.g., Resnick, Levine, & Teasley, 1991), and, of course, in order to experience relatedness (Deci & Ryan, 2000). The lack of social interaction in e-learning might therefore have been a reason for the suboptimal results. Furthermore, *example-based* learning requires active processing of example information. Probably, many students, especially those with little prior knowledge, did not effectively compare their own solutions with the worked examples; it is likely that they could (or would) not use the (standardized) feedback. Especially, weaker or less motivated students might need specific feedback that refers to individual errors and knowledge gaps. Without social interaction and specific feedback students easily develop misconceptions and illusions of understanding (Krause, 2007; Kruger & Dunning, 1999). Therefore, in the present study, cooperative learning and a feedback intervention were implemented. Both interventions should lead to greater effectiveness of the example-based e-learning approach (Krause, 2007; Krause, Stark, & Mandl, 2004).

1.2. Cooperative learning

Cooperative learning is increasingly regarded as an effective means to facilitate learning and higher order thinking (Cohen, 1994). There are several definitions of cooperation and cooperative learning that stress different aspects of it, for example the goal structure or the nature of the task (Slavin, 1983). Based on Cohen (1994) and Slavin (1983), we