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Promoting metacognitive regulation through collaborative problem solving on the web: When scripting does not work

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ABSTRACT

Opportunities for collaborative work can support the process of information problem solving, although this is not a guaranteed outcome of collaborative work. Strong metacognitive regulation is necessary for successful web-based inquiry learning. In the light of these issues, the present study was intended to investigate the regulatory processes that come into play when individual learners work collaboratively in solving information problems on the web and if these can be supported by providing students with a collaboration script. The web-based project was implemented in 12 secondary school classes involving 202 students working in pairs. Six classes were provided with a collaboration script embedded in the learning environment, while the other six classes acted as the control group. Although it was hypothesized that students in the script condition would yield higher shared metacognitive regulation than students in the control condition, based on quantitative as well as qualitative analyses no significant improvement was found that could be attributed to the classroom script intervention. Yet it was found that shared regulation leads to better knowledge co-construction. Moreover, this study confirms that the overall implementation improved students' metacognitive awareness. Results are discussed concerning their theoretical relevance and practical implications for collaborative IPS on the web in face-to-face classroom settings.

1. Introduction

Information and computer technologies and more specific the World Wide Web are receiving increased attention in education because of their potential to support new forms of learning (Roschelle, Pea, Hoadley, Gordin, & Means, 2000). When the World Wide Web is used as a source within inquiry learning this supports the development of higher-order skills such as critical thinking and problem solving (Linn, Clark, & Slotta, 2003) which implies a shift from knowledge transmission to active knowledge construction, aiming at self-regulated and lifelong learning. Although learning in such dynamic learning environments is much more engaging, learning is also much more challenging (Kuiper, Volman, & Terwel, 2009). Many students experience difficulties when receiving learning tasks that require them to find answers on the Internet or to retrieve information for the construction of arguments that can be used in scientific debates (Raes, Schellens, De Wever, & Vanderhoven, 2012). Since the World Wide Web is an extensive source of information, students' adoption of metacognitive regulation is necessary in order to be successful in web-based learning (Brand-Gruwel, Wopereis, & Walraven, 2009). However, contemporary cognitive and educational research has shown that most students have difficulty regulating their learning as well as performing metacognitive activities spontaneously (Lazonder & Rouet, 2008). Supporting metacognitive regulation has consequently become an important educational objective, especially given that adequate metacognition has found to correlate with more active cognitive processing, a better understanding, as well as improved performance (De Backer, Van Keer, Moerkerke, & Valcke, 2016).

New perspectives on metacognition stress the value of collaborative learning for fostering metacognitive regulation (Chiu & Kuo, 2009; Greene & Azevedo, 2010; Järvelä & Hadwin, 2013; Järvelä et al., 2014; Panadero & Järvelä, 2015). When learners work together, they not only benefit from the incorporation of information from multiple sources of knowledge, perspectives, and

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experiences (Lazonder, 2005; OECD, 2013); collaborative learning is also assumed to encourage students into adopting and refining their personal metacognitive regulation and to engage them in social forms of regulation as well. Nevertheless, collaborative problem solving is an inherently complex mechanism since it incorporates the components of cognition and regulation found in individual problem solving, in addition to the components of collaboration (Azevedo, 2014). This means these issues have become even more complex in the case of socially regulated learning. Moreover, students working together must address several difficulties and cognitive, motivational, and socioemotional challenges may emerge; for example, communication challenges, status effects, and emotional differences (Barron, 2003; Hoadley, 2004; Lajoie & Lu, 2012). Good collaboration implies balanced and equal participation in which knowledge is co-constructed and all members contribute different pieces of information or build upon each other's explanations to co-create a complete solution (Sampson & Clark, 2011). In this respect, earlier research recognized the need to know how small groups can be supported to counter and eliminate imbalances and the need to investigate how socially shared metacognitive regulation can be fostered.

Previous research stresses that support can be presented as an instruction that is given before (e.g. providing the RIDE rules consisting of the principles Respect, Intelligent collaboration, Deciding Together, and Encouragement (see Saab, van Joolingen, & van Hout-Wolters, 2007, 2012) or during interaction with the learning environment. A way to provide support during collaboration is providing students with a collaboration script to facilitate social, cognitive and metacognitive processes of collaborative learning by shaping the way learners interact with each other (Kobbe et al., 2007). According to Fischer, Kollar, Stegmann, and Wecker (2013), when speaking about scripts, we need to differentiate between internal and external scripts which are conceived as distinct but largely parallel in structure. An external (collaboration) script is regarded as a scaffold that may induce a functional configuration of an internal script which enables learners to engage in computer-supported collaborative learning (CSCL) practice at a level beyond their ability without an external script (Fischer et al., 2013). Several empirical studies on the effects of external collaboration scripts on CSCL practices showed that these scripts can improve CSCL discourse and (argumentative) knowledge construction (Kollar et al., 2007; Rummel & Spada, 2005; Schoonenboom, 2008; Weinberger, Stegmann, & Fischer, 2010). However, little empirical evidence is available on their effectiveness for eliciting regulation behavior, social forms of metacognitive regulation more particularly, during collaborative problem solving on the web (Azevedo & Hadwin, 2005; Molenaar, van Boxtal, & Sleegers, 2009). Next to this, most scripting studies are conducted in a lab or in an asynchronous, distance setting (e.g. Kahrimanis et al., 2009). Additionally, it needs to be noted that regulation in general is a neglected area in computer-supported collaborative learning research and that there is relatively little research about how groups can be supported to engage in and productively regulate collaborative processes (Azevedo, 2014; Järvelä & Hadwin, 2013; Järvelä et al., 2014).

This paper fills these gaps and presents a study within the context of a web-based collaborative inquiry project designed to improve students' knowledge integration in science and to improve their metacognition in daily classroom practices (see Raes et al. 2012; Raes, Schellens, & De Wever, 2014 for an overview of the overall project objectives and design). More specific, the present study builds upon the importance of metacognitive regulation and aims at unraveling and explaining the impact of collaborative problem solving on the web and the added value of a collaboration script on students' adoption of individual and socially shared metacognitive regulation.

In the following paragraphs, before the research questions and methodology are explained in detail, the main theoretical concepts and underlying assumptions of the present study are elaborated upon.

1.1. Information problem solving on the web and the importance of metacognition

The concept of Information Problem Solving (IPS) combines the skills needed to access and use information, whether or not found on the Internet (Brand-Gruwel et al., 2009; Eisenberg & Berkowitz, 1990). Yet, within this study, we only focus on IPS while using the Web. Within web-based inquiry learning students are often confronted with problems for which information is required to solve it. Understanding how students engage in the processes of search, selection, evaluation, comparison, and integration of ideas from multiple sources of information has become an increasingly important area of research in library and information sciences (Blummer & Kenton, 2014) and in learning and educational sciences (Goldman, Braasch, Wiley, Graesser, & Brodowinska, 2012.; Walraven, Brand-Gruwel, & Boshuizen, 2012; Wecker, Kohnlet, & Fischer, 2007). Goldman et al. (2012) for example used think-aloud protocol methodology to obtain a better understanding of the processing that learners engaged in during a web-based inquiry task on the causes of volcanic eruption: 10 better learners were contrasted with 11 poorer learners and findings suggested that multiple-source comprehension is a dynamic process that involves interplay among sense-making, monitoring, and evaluation processes, all of which promote strategic reading and better learning outcomes. This is consistent with earlier research indicating that the cognitive components of information problem solving include understanding and representing the problem content, applying problem solving strategies, and above all applying metacognitive skills to control and monitor progress toward the goal (Azevedo & Witherspoon, 2009; Funke, 2010).

Since the development of metacognitive awareness is considered to be the key to successful learning (Flavell, 1976), it is important to focus on how we can improve this metacognitive awareness. Metacognition is classically divided into two major components that are metacognitive knowledge and metacognitive regulation. The former can be explained by knowledge about cognition while the latter can be referred as the way for regulation of cognition (Schraw & Moshman, 1995). Knowledge about cognition on the one hand is defined as an awareness of one's strengths and weaknesses, knowledge about strategies and why and when to use those strategies. Regulation of cognition on the other hand is defined as a number of sub processes that facilitates the control aspect of learning, i.e. planning, information management, comprehension monitoring, and evaluation (Schraw & Dennison, 1994). Subsequently, to improve this metacognitive awareness is has been found that students need activities that incorporate reflection, thinking about what they are going to do and why and that metacognition can be improved by guided practice and external modeling or prompting using human tutors or technology-enhanced scaffolding (Schraw, 2007). One particular approach widely known and widely used to teach information skills is the Big6 information problem-solving model (Eisenberg & Berkowitz, 1990). The Big6 integrates information search and use skills along with technology tools in a systematic process to find, use, apply, and evaluate information for specific needs and tasks. One of our own previous studies (Raes et al., 2012) investigated whether the presence of metacognitive and strategic scaffolds based on the Big6 model improved students' domain-specific knowledge and their metacognitive awareness during IPS processes. Results indicated