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The effects of teacher-led class interventions during technology-enhanced science inquiry on students' knowledge integration and basic need satisfaction

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ABSTRACT

This study investigated the effects of two differently designed classroom scripts that guided the teacher-led interventions during the courses of the WISE Climate Change project. 168 students from 10 classes were randomly assigned to either the high-structured condition (teacher interventions on group level and on class level) or the low-structured condition (only teacher interventions on group level). Effects were measured on students' knowledge integration and students' need satisfaction. The results did not provide evidence that the high-structured condition leads to higher learning gains, yet it was found that pausing the group work during computer-supported collaborative learning (CSCL) to provide structure and feedback by the teacher at a whole-classroom plenary level significantly lowered the feelings of competence frustration. Especially low prior knowledge students expressed higher competence frustration in the low-structured condition. These findings suggest to blend CSCL with teacher-led class interventions to optimize the learning environment.

1. Introduction

Although computer-supported collaborative inquiry learning (CSCL) is highly promoted for science education, this kind of learning is much more challenging compared to traditional education which possibly can lead to frustration during learning. Problem-solving environments rely heavily on students' ownership over their learning and depends on students' self-regulated investigations. Yet, students often lack the regulation skills to plan, monitor and evaluate their inquiry (Azevedo, 2005; Kuiper, Volman, & Terwel, 2009; Raes, Schellens, De Wever, & Vanderhoven, 2012). Particularly when students do not have sufficient prior knowledge, naïve assumptions and theories situated in prior experiences and knowledge may limit or fail to adequately inform their inquiry processes (Kirschner, Sweller, & Clark, 2006). Consequently, the challenge is to adequately scaffold students during inquiry learning and find the optimal balance between supporting students' autonomy on the one hand, and making sure that students do not get overwhelmed by the complexity or the frustration that can sometimes arise in doing science inquiry on the other hand (Sierens, Vansteenkiste, Goossens, Soenens, & Dochy, 2009; Tabak & Reiser, 2015). This is in line with the self-determination theory stressing that three basic psychological needs should be satisfied to guarantee students' motivated learning (Vansteenkiste, Sierens, Soenens, Luyckx, & Lens, 2009). To satisfy the need of autonomy, relatedness and competence the learning environment in general and the teacher more specifically need

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to support autonomy, involvement and structure. However, research is lacking to inform how the teacher should intervene during technology-enhanced science inquiry. This study meets this challenge by questioning the teacher's role in scaffolding CSCL from a multi-plane or multi-level perspective. This has done by a quasi-experiment investigating the effects of two differently designed classroom scripts that guided the teacher-led interventions during a technology-enhanced science inquiry project on students' knowledge integration and their need satisfaction. Previous studies that systematically compared the effects of differently scripted activities over social planes on individual learning outcomes are very limited and no studies examined the effects on knowledge integration and competence satisfaction and frustration taking into account possible aptitude-treatment interactions.

1.1. Scaffolding technology-enhanced science inquiry

The notion of scaffolding comes from the socio-constructivist model of learning (Vygotsky, 1978) and was originally introduced by Wood, Bruner, and Ross (1976), who believed that learning occurs in one-on-one interactions in which a more knowledgeable person guides a learner's emerging understanding. In accordance with Vygotsky's zone of proximal development, the scaffold should provide just enough information so that the learner may make progress on his or her own (Hogan & Pressley, 1997). However, the changing teaching and learning context does not allow that privilege, since a teacher cannot interact with every child or small group individually, and in accordance with this changing classroom context, also the notion of scaffolding has changed over time. Recently it has been claimed that during computer-supported collaborative inquiry, scaffolding needs to involve the teacher, peers, and technology (Kim & Hannafin, 2011). Yet, we need to better understand the teacher's contributions to, and interplay among students, peers, and technology in realistic classroom settings (McNeill & Krajcik, 2009; Puntambekar & Kolodner, 2005; Tabak, 2004). In line with the framework of Kim and Hannafin (2011), the notion of orchestration can be put forth which refers to the process of flexibly and productively coordinating the help that the teacher needs to follow, on different social levels or planes, in CSCL environments (Dillenbourg & Hong, 2008; Dillenbourg, 2013; Fischer, Kollar, Mandl, & Haake, 2007). Three planes can be identified on which classroom activities can take place, that is, (1) the individual plane, (2) the group plane, and (3) the plenary or class plane. The different social planes and interactions within and between the planes emerging when implementing CSCL in authentic classrooms are depicted in Fig. 1 based on Dillenbourg and Hong (2008).

1.2. Teacher-enhanced scaffolding on different planes

It is noticeable that teachers have an ambivalent status in theories and studies of collaborative inquiry learning with computers (see e.g. Koschmann, Hall, & Miyake, 2002; Stahl, 2006). On the one hand, a lot of technological innovations in school classrooms have been driven by the aim of transforming teaching and learning from “teacher-led” whole class instruction to more “student-centered” practices which is based on the constructivist learning approach. On the other hand, it has always been recognized that teachers still play a crucial, albeit new, role during computer-supported collaborative inquiry learning activities. Conceptions of the learning process rooted in the notion of scaffolding acknowledge that the teacher, although no longer the “sage on the stage”, nevertheless has to act as a “guide on the side”. However, Dillenbourg (2009) noticed that CSCL cannot have any major impact by putting teachers “on the side”. In line with this, Slotta and Linn (2009, p. 119) suggest that web-based inquiry learning in science can only improve knowledge integration if the teacher acts as a “leader from within” who not only monitors students, but actively intervenes to engage students, helps them to synthesize their views, and maintains a dynamic process of exchange within the classroom. So building deep conceptual understanding

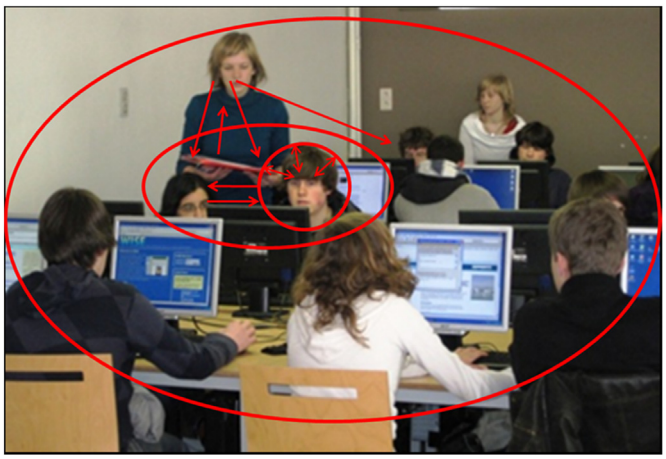

Fig. 1. Different actors at the three social planes emerging when implementing CSCL.