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Exploring gender and gender pairing in the knowledge elaboration processes of students using computer-supported collaborative learning

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ABSTRACT

The aim of the study is to investigate the influence of gender and gender pairing on students' learning performances and knowledge elaboration processes in Computer-Supported Collaborative Learning (CSCL). A sample of ninety-six secondary school students, participated in a two-week experiment. Students were randomly paired and asked to solve several moderately structured problems concerning Newtonian mechanics. Students' pretest and posttest performances were analyzed to see whether students' gender and the gender pairing (mixed or single-gender) were significant factors in their problem solving learning in CSCL. Students' online interactions were also analyzed to unravel the dynamic process of individual knowledge elaboration. The multilevel analyses revealed that a divergent pattern of knowledge elaboration was a significant predictor for students' learning achievement, and in mixed-gender dyads students' knowledge elaboration processes were more inclined to diverge from each other. Moreover, females in single-gender dyads significantly outperformed females in mixed-gender dyads. But this was not the case for male students.

1. Introduction

It seems to be a global problem that physics is confronted with the largest gender gap in school practice. Males tend to outscore female students in physics (Sadker & Sadker, 1994), and females drop out of physics-related majors at a higher rate than do males (Garratt, 1986). Computer-Supported Collaborative Learning (CSCL) affords the opportunity to lessen the gender gap in this regard. It has become a promising heuristic technique in school practice, and in the past decade it has been increasingly applied as an integral part of physics education. In CSCL, students work together to achieve a joint goal such as solving a problem or writing a report. Collaboration involves individual's cognitive elaboration (Stahl, Koschmann, & Suthers, 2006). The effectiveness of CSCL is based on two premises: a) collaborative learning can have profound effects on students' learning achievement (Johnson & Johnson, 1993; Teasley, 1995); b) the promising potential of computers can connect isolated learners in an innovative way (Stahl et al., 2006). Although both premises have already gained sufficient empirical support, both are controversial where gender is concerned.

As for collaboration, although some researchers claim that it appeals to both male and female students (Heller & Lin, 1992; Johnson & Johnson, 1993; Kahle & Meece, 1994), some studies clearly addressed a gender difference in communication styles (Guiller & Durndell, 2006; Lakoff, 1973; Lay, 1992; Li, 2002) and a difference in gender pairing such as single and mixed-gender collaboration in terms of interaction and learning performance (Howe, Tolmie, Anderson, & Mackenzie, 1992). With respect to computer-mediated communication, some researchers have found a gender difference in online language style (Leaper & Smith, 2004; Stewart, Shields, Monolescu, & Taylor, 1999), online communication style (Savicki, Kelley, & Oesterreich, 1999) and participation pattern (Ross, 1996). According to Underwood, Underwood, and Wood (2000), collaborative learning carries risks and these risks are particularly high where computer and gender are involved. Yet, to date, little research has been done to study the influence of gender and gender pairing on students' learning in synchronous CSCL settings. There remain some essential questions that need empirical investigation, such as: Do female and male students benefit equally from mixed- and single-gender dyads in synchronous CSCL? To be explicit, it is still unclear whether the knowledge elaboration process in mixed-gender dyads presents a different picture in comparison with that in single-gender dyad, and how the relationship is moderated by the gender pairing.

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The aim of the current study is to investigate the influence of gender and gender pairing on knowledge elaboration and learning performance in synchronous physics problem solving settings. The research questions are formulated as follows:

- In CSCL for physics problem solving, is there a difference in knowledge elaboration processes between mixed- and single-gender dyads?
- In CSCL for physics problem solving, is there a gender difference in learning achievement?

Exploring these questions will deepen our understanding of the nature of knowledge elaboration processes in online collaboration and provide an insight into an effective instructional design for CSCL. In what follows, a review of knowledge elaboration and gender differences in communication in CSCL will be given. After that, the design of the study will be introduced. Then, we will examine the gender difference in learning performance and knowledge elaboration patterns. In the results section, we will study the relationship between students' gender, knowledge elaboration and learning performance with the help of multilevel analyses. Finally, the research implications will be discussed.

2. Knowledge elaboration in CSCL

Elaborating knowledge defines how students expand and refine new information through organizing, structuring, and connecting with their prior knowledge. Through knowledge elaboration students build up a new understanding of their knowledge. This is an important component of collaborative learning. Collaborative learning hinges on the idea that learners possess different unshared prior knowledge (Weinberger, Stegmann, & Fischer, 2007). When different parts of prior knowledge are shared, combined and reconstructed, collaboration has an added value over individual learning (Pfister, 2005). In dyadic collaboration, each dyad can be viewed as a group with its own properties, but comprised of two relatively independent learners. The learners vary in their degree of contribution to the final result during collaboration. In collaborative learning, according to Roschelle and Teasley (1995), learning is enhanced when learners are engaged in a "coordinated and synchronous activity that is the result of a continued attempt to construct and maintain a shared conception of a problem" (pp.70).

Suthers (2006) distinguished two roles technology plays in CSCL: communication medium and constraint. On the one hand, students' interactions are preserved in a shared context, which may deepen students' thinking and facilitate a high level of elaboration. Moreover, learners have the opportunity to look back at the text that has been exchanged. Explicit back-references such as these afford the opportunity to trigger more thoughtful and reflective discussions. On the other hand, to date, synchronous CSCL is mainly mediated via text-based communication. The learners cannot see each other face-to-face. Such reduced shared context makes it harder for learners to comprehend the meaning of their interlocutor and become fully involved in the discussion (Suthers, 2006). The shared context represents the multiple facets that facilitate the negotiation of interpersonal questions. Moreover, due to the ease of typing and exchanging messages, synchronous CSCL may generate numerous fragmented and incoherent interactions. Interactions in synchronous CSCL are not static but are brief and incomplete (Ding, 2009; Neuage, 2002). Furthermore, Veerman and Veldhuis-Diemanse (2001) found that questions posted in synchronous CSCL tended to be easily ignored. The synchronous interactions were fleeting with short contributions and numerous turns. Weisband (1992) claimed that computer-mediated communication reduces conformity and convergence. Therefore, CSCL may work out in different ways depending on how well students can communicate and elaborate their knowledge mutually.

Koschmann et al. (2005) claim that in computer-supported collaborative learning, knowledge and meaning can be understood as jointly created through interaction which is mediated through computers. In collaborative problem solving, a dyad can be viewed as a unit made up of two interdependent cognitive units (Dillenbourg, Baker, Blaye, & O'Malley, 1995). Hmelo-Silver (2003) points out that the prerequisite for delving into collaborative learning is to make sense of the students' conversation and the tools mediating their roles. Insight into learners' interactions is an important step towards unraveling the dynamic nature of individuals' knowledge elaboration (Arvaja, Salovaara, Hakkinen, & Jarvela, 2007; Brown & Palincsar, 1989). Doing so is based on the rationale that students' discourse data represent their cognitive processes of learning to a certain degree (Chi, 1997). However, there is no consensus regarding how to code students' interactions in an appropriate way (Hmelo-Silver & Bromme, 2007). Some researchers focus on the cognitive quality of students' interactions (e.g. Gudzial & Turns, 2000) because these interactions reflect the state of the students' knowledge. Moreover, representing information and high-level cognitive processing of information are closely intertwined in science problem solving (Kozma & Russel, 1997; Toth, Suthers, & Lesgold, 2002). Analyzing students' text-based and graphical representations during collaborative problem solving can deepen our understanding of students' cognitive contributions towards the solution process and their sharing of meaning (DeWindt-King & Goldin, 2003).

Kumpulainen and Mutanen (1999) differentiated three cognitive dimensions of peer–group interaction by focusing on the nature of cognitive processing. Apart from off-task activities, they distinguished procedural processing and interpretative or exploratory processing activities of individual learners. The researchers described frequencies of these dimensions during collaborative work. Based on that, Ding (2009) endowed each message with an elaboration value: −1, 0 or +1, and plotted the sums of the values for each individual learner along a timeline. For dyadic collaboration, there are two individual curves that may intertwine or not. This visual analysis reveals at least three patterns of knowledge elaboration. The divergent pattern (on the left in Fig. 1), featuring two diverging curves, shows an increasing cognitive discrepancy in interactions between the two participants. The cross pattern (in the middle in Fig. 1) illustrates the fact that students' knowledge elaboration processes are closely intertwined. The participants keep a close eye on their partners' processing and take turns dominating the knowledge elaboration. The parallel pattern (on the right in Fig. 1) shows two roughly parallel curves, indicating that the cognitive gap between the two participants stayed the same during collaboration. With the help of the patterns, we were able to trace the knowledge elaboration processes of the learners and explore the gender difference in CSCL.

3. Gender difference in CSCL

CSCL is assumed to alleviate the gender gap due to the reduced contextual cues. In synchronous computer-mediated communication, students do not see each other and all messages are in text or in graphical representations. Warschauer (1997) suggested that three factors of CSCL contributed to closing the gender gap: 1) the reduced contextual clues masking the gender characteristics; 2) the reduced nonverbal cues such as frowning that can intimidate partners; and 3) the opportunities for students to regulate their learning processes.