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Online versus face-to-face collaboration in the context of a computer-supported modeling task

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ABSTRACT

This paper examines the differences between online synchronous and offline face-to-face collaboration in the context of a computer-supported modeling task. A mathematical problem was designed and set to the participants to solve. Their modeling process using ModellingSpace, a collaborative computer-supported educational environment, was monitored. 16 ninth grade students participated in the study, all worked in groups of two. Eight groups worked online, the remaining 8 offline. The analysis focused on the identification of students' cognitive modeling strategies, their interactions and the learning gain for each type of collaboration. Both qualitative and quantitative approaches were adopted as well as two complementary coding schemes to better investigate the peers' interactions. The results obtained suggest that pairs who worked online emphasized analysis and synthesis; they also demonstrated a higher learning gain. Offline pairs needed the teacher's support and demonstrated stronger social interaction. Moreover, although the actions of offline dyads were more numerous, the dyads that worked online seemed to present more task-oriented actions. Participants in both groups mutually explored the problem, with few disagreements among them. Our findings could inform the design of learning programs and the facilitation of collaborative tasks.

1. Introduction

Collaborative learning is defined as the support provided towards educational goals through a coordinated and shared activity (Dillenbourg, 1999). The size of the group may vary and the learning process depends on the learning object. Commonly applied strategies for collaborative learning are story production, argumentation over an issue, problem-solving (Dillenbourg, 1999). Collaborative learning existed in different fashions and forms even before the era of computational technology. However, new tools that technology introduces should be applied to foster deeper interaction and further development of collaborative learning (Koschmann, 1996). In this context, the design of technologically supported educational tools integrates characteristics of social interaction and communication between peer students, between students and teachers, between amateurs and experts in a specific learning field. Computer-supported collaborative activities differ according to the place (face-to-face or online) and time (synchronous or asynchronous) in which they take place (Avouris, Karagiannidis, & Komis, 2008; Dimitriadis, Karagiannidis, Pomportsis, & Tsiatsos, 2008; Komis, 2004; Koschmann, 1996).

However, the influence of different collaboration types on the learning process, on the student interactions as well as on the students' learning outcome still remains unclear. In particular, it is of significant interest whether synchronous, online collaboration (henceforth 'online' for short) influences the students' interactions and their problem solving approaches differently than synchronous, offline, face-to-face (f2f) collaborative processes (henceforth 'face2face' for short). Several studies examine various factors during the collaborative activity. Basque and Pudelko (2004) report that the difference between online and f2f groups lies in the speed and the ease of the sharing process, which seem to be lower in the online group. The study of Jonassen and Kwon (2001) presents the type of the students' comments and the protocols of their communication in online and f2f communication for a given problem solving activity. The students' comments in the online communication were fewer and were focused mainly on the activity, whereas in f2f communication the students interacted less intensely and followed a linear step sequence. Meyer (2003) argues that the students who worked online better focused on their task and exhibited higher order thinking, whereas f2f students demonstrated direct interactions and more active role engagement. According to Suthers,

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Girardeau, and Hundhausen (2003) students' representations and verbal interactions in online collaboration replace deictic gestures in f2f collaboration. Michinov and Michinov (2008) introduced f2f collaboration during an online collaborative learning session. They observed that as a consequence task-focused interactions and participation were reduced, while issues of coordination and emotional regulation were increased. Another study (Fidas, Komis, Tzanavaris, & Avouris, 2005) examined the way that students collaborative managed to solve a problem using multiple and effective interactions, heterogeneous resourses and divergent capacities. Again, when infusing f2f collaboration in an online setting, each dyad developed more message exchanges, a more complete and concise solution and deeper discussions.

Tutty and Klein (2008) examined the impact of online and f2f collaboration on the students' learning outcome, using post-tests and the total project's assessment. Online groups appeared to be more efficient than f2f groups in the total project, whereas the f2f groups were more successful in the post-test procedure. Comparing the performance between the two environments, Dell, Low, and Wilker (2010) as well as Horspool and Yang (2010) did not find any significant differences in learning performance, though. As a result, they suggest to design tasks that rely on mixtures of online and f2f approaches. Collier and Yoder (2002) suggested some important guidelines concerning the online process, such as carefully prepared instructor interventions, introduction of collaborative oriented tasks, and strategies for motivating inquiry and details for the assignment of roles across the students.

Sins, Savelsbergh, Joolingen, and Hout-Wolters (2011) emphasize both previous factors, i.e. the way the chat influences the students' argumentation and the quality of their output. They base their conclusion on students who work with a computer-supported collaborative environment called Colab. Their study involved 44 students (16–18 years) of mixed abilities. Initially, the students received a lecture for about 2 h related to the Colab tool's functionality. Subsequently, they collaborated in dyads on the task. The students' actions were coded and grouped into 5 large groups: analyzing, inductive reasoning, quantifying, explaining and evaluating. The time spent on the actions' categories was examined and correlated with the result's quality. In general, their performance did not differ between the online and the f2f condition, in online communication the time spent on surface reasoning was found to be significantly shorter, though (Sins et al., 2011).

The aforementioned research results suggest that the specifics of the learning environment and tools used matters much. Therefore, the goal of the study presented in this paper is to closely monitor and analyze synchronous online versus f2f collaboration of students. We focus on students who model mathematical problems using technological tools. A computer-supported modeling procedure was adopted, encompassing model creation and testing using variables, relations and different representations modes. This was done since modeling can be effectively integrated into a problem solving activity (Jonassen, 2006). Moreover, modeling introduces a high cognitive load to the students (Sweller, 1988). The activity was mediated using the ModellingSpace educational software (Dimitracopoulou & Komis, 2005). ModellingSpace is an open learning environment that permits construction and exploration of models of different physical phenomena using various representations in a synchronous collaborative manner. The system uses multiple alternative representations and allows the construction of abstract simulations with appropriate modeling tools. The present study focuses on the special affordances of ModellingSpace (Avouris, Komis, Margaritis, & Fidas, 2004; Dimitracopoulou & Komis, 2005): to foster information exchange and knowledge co-construction within a shared activity space that supports synchronous online conversation (chat), direct manipulation with adequate tools, multiple representations, and rich visualizations of concepts.

In order to design the modeling activity, we took into consideration the following studies. Lazakidou and Retalis (2010) emphasized the importance of the adopted instructional method, because it evokes positive learning gains. In particular, Lazakidou and Retalis (2010) argued that the design consists of three stages: observation, collaboration and semi-structured-guidance, whereas the problem should have a realistic context. However, apart from the pedagogical design aspects that have to be followed, interaction design of the ModellingSpace plays a significant role in how these principals come into real practice. The models that a student can create with ModellingSpace allow the use of qualitative, quantitative and semi-quantitative relations for real world entities that represent primary concepts (Avouris et al., 2004). Thus, learning becomes a side effect of a direct manipulation activity, characterized by actions on objects representing entities or on concepts meaningful to the students. The task of visually representing entities and their properties and the task of simulating their changes according to a chosen relationship support students' abstract thinking and reasoning, which are considered demanding but useful processes for young learners (Dimitracopoulou, Komis, & Teodoro, 2003). Moreover, Panselinas and Komis (2009) examined scaffolding collective thinking as a means of interaction between the students and educational gain. Their findings were used to design the context of the activity presented to the students.

Komis, Ergazaki, and Zogza (2007) provide a novel approach to analyze collaborative modeling tasks. It emphasizes the stages of the cognitive procedure used in the problem solving process; for that reason it was adopted as the basic analysis tool in the present study. The approach is based on the activity theory (Engeström, Miettinen, & Punamaki, 1999), on the model analysis OCAF (Avouris, Dimitracopoulou, & Komis, 2003) and on the approach introduced by Stratford, Krajcik, and Soloway (1998) for cognitive strategies' modeling. In addition, the theory of Mercer (1995) on the types of interactions that participants produce (disputational talk, cumulative talk, exploratory talk) was also adopted, as a means to better anticipate the collaboration process.

The specific questions of the study are:

(a) How, if at all, does the collaboration's type influence the students' modeling processes while solving a mathematical problem?
(b) Do the interactions of the students who worked online differ significantly from the students who worked f2f?
(c) Are the students' learning outcomes different for the two collaboration types?

2. Method

2.1. Research design

A mixed research method was adopted, using both qualitative and quantitative approaches. The aspects to meditate when planning a mixed method are timing, weighting and blending the two kinds of data regarding the two methods (Creswell, 2009). In the present study, emphasis was given to the qualitative research, while the data were combined during the interpretation stage. The participants' actions were encoded in order to identify patterns and types of collaboration. In addition, a case study design was adopted in order to obtain a precise and complete view of the collaboration process (Cohen, Manion, & Morrison, 2008). The case study is considered an appropriate method in the context of collaborative learning, since it emphasizes the exact environment of each research setting (Avouris et al., 2008).

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