

Running head: COLLABORATIVE LEARNING AND ICT

Collaborative Learning and ICT: The Flemish Experiences
M. Valcke, Chiluiza, M. De Smet, B. De Wever, T. Schellens, S. Timmers, H. Van Keer
Department of Education, Ghent University, Belgium

Correspondence should be addressed to Martin Valcke, Department of Education, Ghent University, Belgium. Voice: +32 9 264 8675; Fax: +32 9 264 8688 Email: martin.valcke@ugent.be

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Collaborative Learning and ICT: The Flemish Experiences

Since 2000, following a thorough restructuring of its research program, ICT and collaborative learning have become established and dominant research themes at the Department of Education at Ghent University, Belgium. In this article, we first outline the theoretical base shared in most studies, after which we discuss a number of empirical studies carried out in a variety of settings, such as university teaching (education, medicine, and pharmacy) and primary school.

Theoretical Base

Although most of the Ghent studies can be positioned within the context of social constructivist teaching and learning assumptions, the empirical studies focus primarily on social cognitive assumptions about the impact of collaboration in instructional settings. Figure 1 gives a schematic representation of this theoretical base (for comparable approaches see Baker, 1996; Doise & Mugny, 1984; Erkens, 1997; Kreijns & Bitter-Rijkema, 2002; Petraglia, 1997; Savery & Duffy, 1996).

****INSERT FIGURE 1 ABOUT HERE****

The figure depicts the information processing activity of individual students, and how this individual activity is set up in an ICT-enriched environment. Via these ICT-tools - such as computer supported collaborative environments (asynchronous discussion groups) and mindtools (Logo Microworlds® and Lego-Logo®) - the students exchange and share knowledge. This results in output (processed information) and input (information to be processed). This input-output exchange can be influenced by the ICT-tools

The ICT-tools can, on the one hand, foster information processing activity, building on the assumption that learners actively engage in cognitive processing to construct mental models (or schemas) based on individual experiences. In this way, new information is integrated into existing mental models. This *active processing assumption* invokes three types of processes in and between working and long-term memory: selecting information, organizing information, and integrating information (Mayer, 2001). The mental models that are constructed are stored in and retrieved from long-term memory. Because of the importance of prior experiences and knowledge, characteristics of the individual learner (e.g., attitude towards the learning environment and group discussions and learning styles) are considered of importance. Moreover, it is hypothesized that the more students express their line of thought, the more the construction of mental models is facilitated. Therefore the amount of individual contributions is regarded as relevant. The ICT-tools can, on the other hand, foster the exchange of information *between* students. This information is pre-structured, reflecting multiple perspectives, commented upon, and is hypothesized to be more readily accessible by peers. This assumption is essential, for example in the cognitive flexibility theory of Spiro, Feltovich, Jacobsen, and Coulson (1988).

As will be explained in the overview of the empirical studies, independent variables have been studied at the level of the individual student, the groups, and the tasks put forward. In the ICT-based learning environment dependent variables were related to levels of knowledge construction, performance outcomes, conceptions of learning, and attitudes. In all the studies, student involvement was part of the formal instructional setting. Since the nature of this article obliges us to restrict elaboration of each study, those interested in the details of the different studies can contact the individual authors to obtain more information.

The Impact of CSCL on University Learning

The impact of collaboration in computer supported collaborative learning (CSCL) environments on study performance and the nature and quality of knowledge construction in

university learning has been studied during four subsequent years (Schellens, 2004; Schellens & Valcke, in press(a), in press(b), 2000, 2002, 2004; Schellens, Van Keer & Valcke, 2004a, 2004b).

In a first study 300 of the 850 freshman students studying Psychology and Educational Sciences participated. They worked four months in 38 asynchronous discussion groups on authentic tasks and problems in which they applied the theoretical base of different instructional theories. Group size was manipulated in this study. The complete CSCL-transcripts (1759 messages) of nine groups were analysed to determine the level of knowledge construction reflected in these messages, using the models of Fahy, Crawford, Ally, Cookson, Keller, and Prosser (2001) and Veerman and Veldhuis-Diermanse (2001). The model of Fahy and colleagues helps determine the level of knowledge construction, namely (1) vertical questions, (2) horizontal questions, (3) statements, (4) reflections, and (5) scaffolding. Veerman and Veldhuis-Diermanse present an analysis model to distinguish between non-task related input, such as planning, technical contributions, or social contributions on the one hand, and task-related input, such as presentation of new facts, presentation of new experiences or opinions, presentation of new theoretical ideas, explicitation, and evaluation on the other hand. The results of this study confirm the task-related nature of the group communication. Building on the hypothetical hierarchical nature in the levels of knowledge construction, the results further reveal higher proportions of high phases of knowledge construction in all groups. As to the variable group size, smaller groups (N=8-10) reached significantly higher levels of knowledge construction than average size (N=11-13) and large groups (N=15-18).

In a subsequent study, 230 freshmen worked in 23 asynchronous discussion groups as a formal part of their curriculum. Group size was constant in this study (N=10) and the focus was on determining the impact of task structure (global task versus pre-structured task) and participation levels (3 levels, based on the number of observed contributions in the group discussions) on knowledge construction. Again complete transcripts (N=1428) of eight randomly selected discussion groups were analyzed by applying the content analysis model of Veerman and Veldhuis-Diermanse (2001) and the model of Gunawardena, Lowe, and Anderson (1997) which distinguishes five hierarchical phases, namely (1) sharing and comparing information, (2) discovery and exploration of dissonance or inconsistency, (3) negotiating meaning and co-construction of knowledge, (4) testing tentative constructions, and (5) statements and application of newly constructed knowledge. The results again confirm the highly task-oriented nature of the discussions. Discussions in more actively engaged groups (reflecting the highest participation level) reflect significantly higher levels of knowledge construction (Model Gunawardena et al., $X^2(8) 192.66, p < .01$; Model Veerman et al., $X^2(8) 117.52, p < .01$). The findings also hint at a significant impact of task structure. More complex tasks foster higher levels of knowledge construction.

In a third study (N=286), multi-level analysis was applied to determine the impact of individual student characteristics (i.e., positive attitude towards CSCL; deep, surface, or strategic learning style; participation level), group characteristics (i.e., activity level), and task characteristics (i.e., role assignment, task complexity) on two dependent variables, namely levels of knowledge construction and study performance. To determine the levels of knowledge construction, the same models were applied to code the transcripts (N= 1933) as in the second study. With respect to the in-depth exploration of the task environment, task complexity (availability of conceptual base and availability of a solution procedure) was measured and considered to have a differential impact. When the tasks are too complex, the levels of knowledge construction are significantly lower. On the other hand, when tasks are too straightforward, we might expect that students experience no challenge and the number and quality of contributions

also drop. Next, students received one of the following roles to guide their work in the discussion groups: 'moderator', 'theoretician', 'summarizer', or 'source searcher'. The roles were randomly assigned to four students in each group. At the start of every new discussion assignment, the roles were assigned to four other students within the same group. The approach is comparable to the collaboration script approach of O'Donnell and Dansereau (1992).

The results of this study point at the impact task complexity. When tasks are too complex, the levels of knowledge construction are significantly lower. On the other hand, when the tasks are too straightforward, the number and the quality of the contributions drop significantly. The results confirmed earlier findings that a task should be in the learners' zone of proximal development (Schellens et al., 2004a; Quinn, 1997). With respect to the impact of roles, only the role of the 'summarizer' resulted in significantly higher levels of knowledge construction. This points to a possible need to refine the global design guidelines on scripting student contributions in CSCL-settings (e.g., Weinberger, 2003). Considering the results of the multi-level analysis dealing with student, group, and task variables, a large part of the overall variance in students' levels of knowledge construction can be attributed to differences between the various discussion themes and tasks. As to the impact of student characteristics, the amount of individual contributions and students' attitude towards the online learning environment are significant predictors of students' mean level of knowledge construction.

Based on the findings of these studies and taking into account the concern that collaboration as such does not systematically result in learning (e.g. Dillenbourg, 2002), a new set of studies was set up, focusing on the impact of structuring task and discourse on students' levels of knowledge construction and appreciation of the asynchronous discussion groups.

In a first phase of research the implementation of roles, as described above, was optimized. In the second phase (De Wever, Van Keer, Schellens, & Valcke, in preparation), task structure was implemented by introducing self-assessment to encourage independent and self-directed learning which is congruent with the goals of peer learning (Boud, 1995; Falchikov, 2001). Moreover, research reveals considerable impact of self-assessment on students' self-reflection, content-related learning, and quality of problem solving (Sluijsmans, Dochy, & Moerkerke, 1999). In a third phase peer tutoring was introduced as an approach to structure CSCL-tasks.

Peer Tutoring in CSCL-Settings

In the peer tutoring study, fourth-year 'Educational Sciences' students took up the role of cross-age peer tutors in the asynchronous discussion groups. Tutoring is the process of helping learners acquire the necessary knowledge, tools, and strategies to be successful in meeting academic assignments dealt with in discussion groups (Topping, 1996).

This research focuses on studying the freshmen's knowledge construction processes in tutored groups on the one hand and on tutors' input while facilitating freshmen's learning processes on the other hand. Tutors were trained to acquire necessary metacognitive and social strategies to moderate the discussion groups. The emphasis here was on the evolution of tutor activities from moderating to coaching, implying a gradual transition from tutor-centered activities to student-centered learning activities (Moust & Schmidt, 1994).

In a first study (De Smet, Van Keer, De Wever, & Valcke, 2005), 19 pairs of tutors supported 19 discussion groups comprising 9 to 11 freshmen. During 12 weeks, the tutors supported the freshmen tackling six authentic tasks (two weeks per task). Content analysis was carried out on the tutors' input. An interaction-based coding scheme was developed, rooted in two existing instruments: a framework to analyze argumentative knowledge construction in CSCL (Weinberger & Fisher, 2004) and the Community of Inquiry Coding Template (Garrison,

Anderson, & Archer, 2000). The instrument focuses on the tutors' social and organizational support, support of learning content, and support by modeling or eliciting argumentative knowledge construction. The results of this ongoing study point towards the importance of identifying a typology of tutoring activities in online discussion groups. A distinction can apparently be made between tutors that strongly structure the components, tutors who are good motivators, and tutors focusing on the learning content.

CSCL and Medical and Pharmacy Students

The research described thus far has been in the domain of the Educational Sciences. In order to study the applicability of the CSCL design guidelines, a variety of studies has been set up in other knowledge domains, building on the previous experiences. An example is the integration of the CSCL-setting in a clinical internship in pediatrics at the Ghent University Hospital. Online case-based discussion groups were introduced since interference with ward-based activities and staff-schedules prevented the expansion of face-to-face case discussions. A first study (De Wever, Valcke, Van Winckel, & Kerkhof, 2002) focused on the impact of task scripting on students' knowledge construction processes. In the online case discussions where task scripting was involved, students had two elaborated procedures for patient management at their disposal when discussing a medical case. Students in the non-scripting condition had to elaborate on further patient management themselves before commencing the discussion. The results of this study confirm the earlier results and point at the significant impact of CSCL-scripts. Current research (De Wever, Valcke, & Van Winckel, 2005) tries to validate the impact of role assignment as a scripting tool.

Another study is set up in the pharmaceutical knowledge domain. In a period of four months, fifth-year students solve pharmaceutical cases in asynchronous discussion groups as part of their internship (Timmers & Valcke, 2005). The study focuses on the impact of these discussions on the self-reported acquisition of pharmaceutical competencies, the appreciation of the learning environment, and the direct application of the knowledge base. The transcripts of the discussions are analyzed for the presence of indicators pointing to the declarative and procedural knowledge-base elements needed to solve the cases. Moreover, in a number of discussion groups two different roles (moderator and summarizer) are randomly assigned to students. The preliminary results of this study point to the significant impact on the – self-reported – acquisition of pharmaceutical competencies (as compared to previous cohorts), appreciation of the learning environment and the significant impact of roles in discussion groups on the application of the knowledge base.

The Impact of Mindtools on Teachers and Students

A separate sequence of quasi-experimental studies was set up during two consecutive years in the Santa Elena Peninsula of Ecuador. The evaluation studies involved 43 schools and over 10,000 students in the context of the large-scale Innovation of Education in the Peninsula Santa Elena project. Eight fifth-grade classes ($N=249$) and their teachers were involved in this study. Students of three classes in the experimental condition worked in small groups with mindtools (Lego-Logo® and Logo Microworlds®). These group activities focused on projects in which science topics were integrated in authentic tasks. Along with studying the impact of the use of ICT on the students, the teaching practices during regular classroom activities were also studied (Chiluiza, 2004).

At the student level, tests were administered at the beginning, in the middle, and at the end of both years. Test administration focused on mathematics performance (TIMSS test), cognitive style (GEFT test; Witkin et al., 1971) and the perception of the students as to the adoption of social constructivist teaching principles by their teachers (CLES-test; Taylor, Fraser

& Fisher, 1997). Next, student collaborative behavior was videotaped to determine the levels of cognitive processing mirrored in the student interaction, based on Gunawardena and colleagues (1997). The results are clear, the mindtool-based collaborative activities have a significant differential impact on students in the experimental condition. They reach higher levels of cognitive processing to a higher extent. But in general, the overall levels of cognitive processing remained rather low. Only marginally significant higher mathematics scores were obtained by students working with the mindtools.

At the teacher level, the study focused on the impact of the use of mindtools on teachers' regular teaching activities (non-ICT related). To determine this, science teaching activities were videotaped and analyzed with the Constructivist Teaching Inventory (Greer, 1997). Next, teachers also filled out the Constructivist Learning Environment Survey to rate their own teaching behavior (Taylor et al., 1997). The video analysis results point at a significant impact. The teachers adopted social-constructivist teaching principles in their practices to a significantly higher extent. However, relatively low levels of adoption were observed overall. Interestingly, student perceptions about the adoption of the principles by their teachers aligned with the actual levels of adoption observed by the researchers in the classroom setting.

Conclusions and Practical Implications

The findings of the Ghent studies are largely in line with the results of studies that fit into the long tradition of collaborative and cooperative learning research. The nature of the ICT-learning environments required the researchers to go beyond the empirical evidence present in the review studies and meta-analyses of for example Johnson and Johnson (1994) and Slavin (1995). Apart from the clear focus of the Ghent researchers to ascertain clear empirical evidence to ground assumptions about collaborative learning, the studies especially aim at grounding design guidelines to direct future research and practice. This also explains why the studies have been set up as "series" of studies. The research approach exemplifies a design-based research methodology in which the theory-driven research is targeted at refining design guidelines and the detection of influencing variables in the instructional setting.

As to practical implications, in addition to the clear design guidelines of Johnson and Johnson (1996) such as positive interdependence, individual and group accountability, evaluation of both the group and each individual, and social skills that help to guarantee that true cooperation will be observed in groups, a number of important guidelines for designing collaborative learning environments in asynchronous discussion groups can be derived from the studies presented above. A first set of guidelines is closely connected to the design of the tasks. The research results reveal that task structure is an important issue to consider for developers of CSCL-environments. A careful balance should be respected between open and closed structure of the discussion. Along with the task structure, task complexity is also a significant factor. Tasks should not be too complex, as students' motivation might decline. Illera (2001) states that motivation also implies that students are capable of seeing that they can complete the activity that is within their zone of proximal development and that it is not something unattainable. On the other hand, when tasks are too straightforward, we might expect that students experience no challenge and the quality of contributions also drop. It appears that challenge is an important concept in this context. In order to keep the learning in this zone of proximal development we can also point at the importance of structuring the assignments in CSCL environments through for instance role assignment, self assessment, and peer tutoring.

An additional practical implication is that tasks should be enjoyable. When students are engaged, they participate more often, leading to the intended results. The importance of student engagement leads us to a second set of guidelines. Instructional designers should stimulate

student participation and promote the active use of the online learning environment. In this respect, there are a number of recognized strategies designers should consider. These strategies are consistent with constructivist approaches to learning and instruction to foster engagement in an online learning environment: present achievable goals and clear evaluation criteria, organize authentic learning, and set tasks at the appropriate level of complexity.

A last guideline is to provide technical support to the students. Especially at the onset of the discussions, a well functioning helpdesk, or – if necessary – demonstrations, can be essential.

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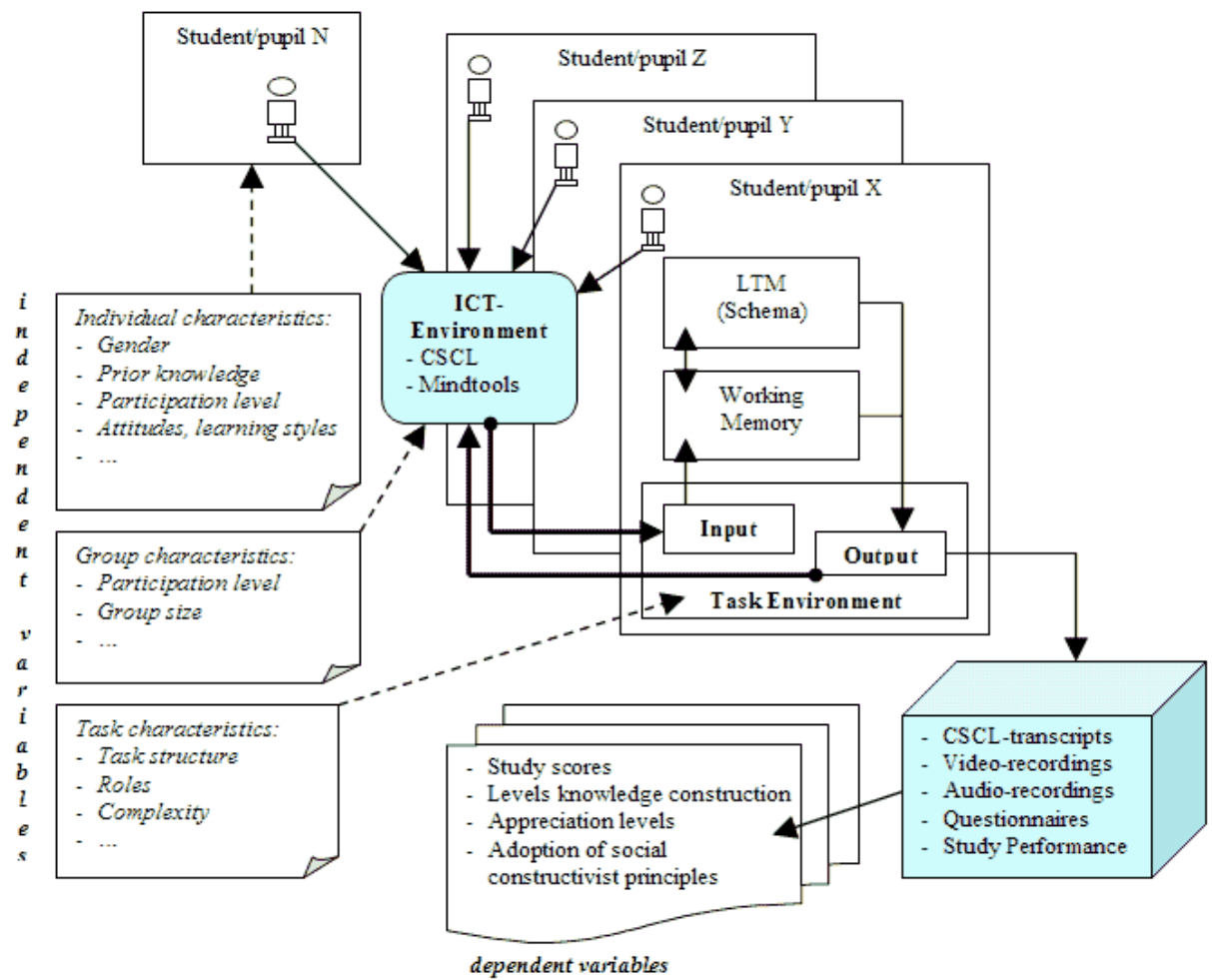
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Figure Captions

Figure 1: Theoretical interaction of processes and variables in the Ghent studies.

Figure 1



Martin Valcke is head of the Department of Education at the Ghent University. As a professor in Educational Sciences, he coordinates higher education innovation research with a strong focus on the integrated use of Information and Communication Technologies (ICT) and management issues. His other expertise areas comprise performance indicator research, the design of multimedia learning materials, teacher training and individual differences (**e-mail: martin.valcke@ugent.be**).

K. Chiluiza is doctor in educational sciences at the Ecuadorian University Escuela Superior Politecnica del Litoral (ESPOL) in Guayaquil. Her research centers on teacher training and the use of ICT and the cognitive impact of integrated ICT-use in primary schools (**e-mail: kchilui@espol.edu.ec**).

Marijke De Smet is a PhD student in the Department of Education of the Ghent University. Her research focuses on the impact of peer-tutoring and coaching in computer supported collaborative learning environments (**e-mail: marijke.desmet@ugent.be**).

Bram De Wever is a PhD student in the Department of Education of the Ghent University. His research deals with the cognitive impact of adding scripting approaches (role-assignment, self-assessment, peer-tutoring) to computer supported collaborative learning environments (**e-mail: bram.deweever@ugent.be**).

Tammy Schellens is doctor in Educational Sciences in the Department of Education of the Ghent University. Her PhD research was related to the impact of studying in a computer supported collaborative learning environments (CSCL) on knowledge construction in higher education (**e-mail: tammy.schellens@ugent.be**).

Sofie Timmers is a PhD student in the Department of Education and Faculty of Pharmacy of the Ghent University. Her research centers on the integrated use of CSCL in practicals of senior students in pharmaceutical sciences. She studies the impact of CSCL on competency development (**e-mail: sofie.timmers@ugent.be**).

Hilde Van Keer is doctor in Education Sciences in the Department of Education of the Ghent University. Her research focuses on peer-tutoring in a variety of knowledge domains and educational contexts. Next to studies about peer tutoring and reading comprehension, she coordinates research on CSCL and e-coaching skills (**e-mail: hilde.vankeer@ugent.be**).