Measurement and assessment in computer-supported collaborative learning

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A R T I C L E   I N F O

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A B S T R A C T

The overall goal of CSCL research is to design software tools and collaborative environments that facilitate social knowledge construction via a valuable assortment of methodologies, theoretical and operational definitions, and multiple structures [Hadwin, A. F., Gress, C. L. Z., & Page, J. (2006). Toward standards for reporting research: a review of the literature on computer-supported collaborative learning. In Paper presented at the 6th IEEE International Conference on Advanced Learning Technologies, Kerkrade, Netherlands; Lehtinen, E. (2003). Computer-supported collaborative learning: an approach to powerful learning environments. In E. De Corte, L. Verschaffel, N. Entwistle & J. Van Merriëboer (Eds.), Unraveling basic components and dimensions of powerful learning environments (pp. 35–53). Amsterdam, Netherlands: Elsevier]. Various CSCL tools attempt to support constructs associated with effective collaboration, such as awareness tools to support positive social interaction [Carroll, J. M., Neale, D. C., Isenhour, P. L., Rosson, M. B., & McCrickard, D. S. (2003). Notification and awareness: Synchronizing task-oriented collaborative activity. International Journal of Human–Computer Studies 58, 605] and negotiation tools to support group social skills and discussions [Beers, P. J., Boshuizen, H. P. A. E., Kirschner, P. A., & Gijselaers, W. H. (2005). Computer support for knowledge construction in collaborative learning environments. Computers in Human Behavior 21, 623–643], yet few studies developed or used pre-existing measures to evaluate these tools in relation to the above constructs. This paper describes a review of the measures used in CSCL to answer three fundamental questions: (a) What measures are utilized in CSCL research? (b) Do measures examine the effectiveness of attempts to facilitate, support, and sustain CSCL? And (c) When are the measures administered? Our review has six key findings: there is a plethora of self-report yet a paucity of baseline information above collaboration and collaborative activities, findings in the field are dominated by ‘after collaboration’ measurement, there is little replication and an over reliance on text-based measures, and an insufficient collection of tools and measures for examining processes involved in CSCL.

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1. Introduction

Computer-supported collaborative learning (CSCL) is one of the more dynamic research directions in educational psychology. Computers and various software programs were incorporated into education to aid the administration and measurement of solo and collaborative learning activities because software can: (a) be individualized in design and use, (b) represent problems more realistically, (c) display each step of a difficult problem solving task, (d) afford group discussion and collaboration across distances, and (e) provide immediate feedback for monitoring and evaluating student progress [Baker & Mayer, 1999; Baker & O’Neil, 2002; Schacter, Herli, Chung, Dennis, & O’Neil, 1999]. Not surprisingly the increased prevalence and benefits of computer use in collaboration has spawned new directions for research in the field of educational psychology and beyond, demonstrated by studies in the learning sciences, computer science, human computer interaction, instructional psychology, educational technology, and education (Baker & Mayer, 1999; Hadwin, Winne, & Nesbit, 2005; Lehtinen, 2003).

The overall goal of CSCL research is to design software tools and collaborative environments that facilitate social knowledge construction via a valuable assortment of methodologies, theoretical and operational definitions, and multiple structures (Hadwin, Gress, & Page, 2006; Lehtinen, 2003). CSCL environments such as CSILE/Knowledge Forum (Lipponen, 2000; Salovaara & Järvelä, 2007). Portions of this paper were presented at the Annual Meeting of the Canadian Society for the Study of Education, York University, Toronto, ON, May 26–30, 2006. Support for this research was provided by grants from the Social Sciences and Humanities Research Council of Canada to A. F. Hadwin (410-2001-1263), P. H. Winne (410-2001-1263), and P. H. Winne (principal investigator) and A. F. Hadwin (co-investigator) (512-2003-1012).

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2. Measurement in CSCL

Measurement in CSCL consists of observing, capturing, and summarizing complex individual and group behaviours, from which researchers make reasonable inferences about learning processes and products. Factors affecting measurement in CSCL include individual differences, context, tool use, collaborative activities, and various theoretical backgrounds of the researchers and instructors. These inferences and interpretations form assessments which play a central role in guiding and driving student learning toward knowledge acquisition and learning outcomes (Chapman, 2003; Knight & Knight, 1995; Macdonald, 2003). Assessment targets learner’s outcomes and it infuses instruction with objective information, to stimulate deeper knowledge and motivate personal goals in students and educators (Baker & O’Neil, 2002). Measurement and assessment in CSCL can take one of three forms: assessing the individual about the individual, assessing the individual about the group, and assessing the group as a whole.

We are interested in the measurement of individual and shared learning processes, the steps each learner takes and retakes as they progress towards a learning outcome, typically tracked by process products such as notes, drafts, discussions, and traces of learner to learner and learner to computer interactions. Of particular interest is the measurement of process products in real time and to find a way to summarize and present these products to learners to provide opportunities for them to monitor, evaluate, and adapt their learning during collaborative activities. For example, Punthambekar and Luckin (2003) and Baker and O’Neill (2002) suggested learners gain a better understanding of their learning processes when provided opportunities to reflect on their collaborative learning products, such as notes, conversations, drafts, group management skills, and so on. These reflection opportunities arise when instructors or software programs provide real-time analysis of the artifacts learners produce, such as chat records, drafts, and learning objects, and process statistics, such as traces of learner-software interactions (Hmelo-Silver, 2003). Process measurement and real-time analysis, however, is highly complex and challenging, as it includes (a) measuring the cognitive steps taken by the individual and the group in the collaborative process requires, (b) measuring individual differences in these steps, (c) designing meaningful assessments of the processes, and (d) developing analytical methods for understanding and analyzing collaborative processes and products, which includes dealing with a wide variety of interaction types and developing means for automatically and efficiently processing collaborative process data (logs and tracings) and products (demonstrations of learned skills and content) so it can be viewed by learners, educators and researchers (Lehtinen, 2003; Martínez, Dimitriadis, Rubia, Gómez, & de la Fuente, 2003), adapting methods for different contexts (Punthambekar & Luckin, 2003).

3. Purpose of this paper

This paper stems from a literature review that identified current methods of measuring and assessing learning processes in CSCL. We wanted our comprehensive review of measurement tools and methods used in CSCL to describe the current state of the literature by answering three fundamental questions: (a) What measures are utilized in CSCL research? (b) Do measures examine the effectiveness of attempts to facilitate, support, and sustain CSCL? And (c) When are the measures administered? For example, collaboration typically includes student-centered small group activities, in which learners develop the necessary skills to share the responsibility of being active, critical, creative co-constructors of learning processes and products. Conditions shown to facilitate and influence collaboration include, for example, positive interdependence, positive social interaction, individual and group accountability, interpersonal and group social skills, and group processes (Kreijns, Kirschner, & Jochems, 2003). Various CSCL tools attempt to support these constructs, such as awareness tools to support positive social interaction (Carroll, Neale, Isenhour, Rosson, & McErickard, 2003) and negotiation tools to support group social skills and discussions (Beers, Boshuizen, Kirschner, & Gijselaers, 2005), yet few studies evaluate these tools in relation to the above conditions. They focus instead on comparing collaborative products or investigating tool usability or tool effects on collaborative products.

This paper describes the findings of our review. First, we answer the three questions stated above. Second, framed by our coding to meet the first objective, we highlight key findings and discuss potential directions for CSCL research. Finally, we will explore how future research in CSCL the Learning Kit project might contribute to developing a systematic and thorough approach for measuring collaborative processes and products using gStudy (Winne, Hadwin, & Gress, this issue; Winne et al., 2006).

4. Method

We conducted an extensive literature search for all articles related to CSCL from January 1999 to September 2006 in five academic databases: Academic Search Elite, Computer Science Index (which includes IEEE and ED/ITLib, formerly the AACE Digital Library), ERIC, PsycArticles, and PsycInfo. Search terms included variations and combinations of computer, collaboration, and learning. After the search, we focused on empirical studies, including case studies, as long as the focus of the study was collaboration among learners, not software usability (23 studies), resulting in 186 articles. We acknowledge that some studies may be missing from this analysis but we felt 186 articles should provide a strong representation of the field.

Initially we critically reviewed and coded each article to delineate contextual aspects of the literature, clarifying five broad aspects of CSCL research (see Gress et al., this issue): (1) the focus of the article (for example, was it CSCL, computer-supported collaborative work, computer-supported problem solving, or computer-mediated communication); (2) whether or not the technology proposed was designed to provide a CSCL environment or if the technology was add on, such as email, or stand alone chat; (3) models of collaboration, defining mode and purpose of communication, level of knowledge construction, group membership, and individual access to the group project; (4) collaborative tools; and (5) collaborative support. Discrepancies were resolved through discussion to consensus between researchers.

For this paper, we added a sixth coding category, research methods and design. We were interested in three main attributes of existing CSCL research: constructs of interest, measures and
methods, and measurement timing. To aid us in this task, we coded the following information.

4.1. Research question

In this category, we identified the research questions or statements provided by the author(s); for example “this paper describes a case study that investigated students’ sociocognitive processes in a multimedia-based science learning task. By focusing on students’ discursive, cognitive and collaborative activity on a micro analytic level, the study describes the nature of students’ strategic activity and social interaction whilst handling and processing information from a multimedia CD-ROM science encyclopaedia” (Kumpulainen, Salovaara, & Mutanen, 2001, p. 481);

4.2. Constructs of interest

In this category we identified the particular constructs of interest, for example, anonymity in chat (Barreto & Ellemers, 2002), awareness (Carroll et al., 2003), knowledge construction (Beers et al., 2005), and efficacy (King, 2003).

4.3. Measures, methods, and timing

First, we identified all the various measures, such as questionnaires and interviews, and methods, such as observations, discourse analysis, or trace data, used in collaborative research. We then grouped these measures and methods according to assessment timing (before, during, or after collaborative task[s]). Within the three categories of measurement timing, we divided the measures and methods into six main categories of measurement identified in the first step: self-report, interview, observation, trace data, discussion/dialogue, performance/product, and feedback. The purpose of delineating the measures and methods within the framework of assessment timing was to highlight what measures are used and when and what constructs have been overlooked.

5. Results

As stated above, we conducted a review of the CSCL literature to answer three fundamental questions: (a) What measures are utilized in CSCL research? (b) Do measures examine the effectiveness of attempts to facilitate, support, and sustain CSCL? And (c) When are the measures administered? To answer these questions, we focussed on identifying the measures used to assess collaborative constructs in CSCL, when they measure these constructs, and the constructs or information of interest.

5.1. What measures are utilized in CSCL research and when?

We evaluated 186 empirical articles and found these studies incorporated 340 measures (and methods) of collaborative constructs (see Table 1). The majority of these measures were self-report questionnaires (33%) and products of collaboration (19%) assessing individual differences associated with collaboration as well as collaborative learning and knowledge construction. The number of measures used to assess process data and discussion and dialogues were approximately equal at 12%, followed by interview data (10%), observations (9%), and then prediction and/or feedback (5%). These numbers suggest much of the information known about collaborative processes and products is from the first two forms of measurement available in CSCL: self-report measures that assess the individual about the individual, and the individual about the group. This is not surprising considering the ease of administration, low cost, and flexible nature of self-report measures.

Of the three approximate times during which collaboration was assessed (before, during, and after), our review reveals the majority

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<th>Table 1</th>
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<td>Coding framework: categories, measures, and examples</td>
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<td>Category</td>
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<tr>
<td>Self-report</td>
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of measures used to assess some aspect of collaboration were administered after collaborative activity (51%), followed by during the activity (35%), while only 14% of the studies gathered baseline data of the collaborative construct of interest before the actual activity. This suggests the lion’s share of information gained from CSCL studies is measured after collaborative activity, i.e. after potential changes to an individual’s learning processes and skills have occurred, and is based on the final products of collaboration rather than the process.

A more detailed look at the review data uncovered some predictable patterns. As expected, some measures are better suited to assessments at certain times than others, such as self-report questionnaires for before and after activities and process measurements or observations during collaborative activities. As we can see in Table 2, the majority of studies assessing collaboration in the before collaboration time slot used self-report questionnaires (74% of before measures, 10% of total measures) followed by performance indicators (11% of before, 1.5% of total measures), interviews (6% of before, 1% of total), with predictions or initial CSCL feedback and coded discussion data tied for last (4% of before, .6% of total measures). Studies measuring collaborative constructs during collaboration did so mostly via discussion or dialogues and process data such as timing, frequency, and/or traces (each approximately 32% of during measures, 11% of total), followed by observations (video or live) (22.5% of during measures, 8% of total), self-report (5% of during, 2% of total), interviews (4% of during, 1.5% of total), performance (3% of during, 1% of total), and feedback (1% of during, .3% of total).

As stated previously, most studies incorporated collaborative measurement after collaborative activity. These consisted mainly of self-report questionnaires (41% of after measures, 21% of total), followed by performance and product (33% of after, 17% of total), interview (15% of after, 8% of total), feedback (9% of after, 4% of total), observations of after collaborative behaviours and skills and discussion data (each 1% of after, .6% of total).

5.2. Do measures examine the effectiveness of facilitating, supporting, and sustaining CSCL?

5.2.1. Before collaboration

Our review revealed the measures can be collapsed into three categories: individual difference measures, standardized testing, and baseline information. As demonstrated in Table 3, individual difference measures included measures on individual and collaborative learning attitudes and skills, epistemological beliefs, computer skills and experience, motivation, and instructional planning and beliefs, and so on. Standardized testing included the occasional pre-screening for learning disabilities or an achievement test. Baseline information included pre-tests on content or experience, grade point averages, examples of work pre-intervention, and predictions by learners and instructors on participant experience, grade point averages, examples of work prior to activities (e.g. Fischer, Bruhn, Grasel, and Voss, 2006). Our review also revealed that some of those individuals may not be ready to collaborate. The current literature, however, does not suggest a way to assess the state of collaborative readiness. Nardi (2005) begins to address this issue in her work on communicative readiness, a state in which “fruitful communication is likely” (p. 91).

5.2.2. During collaboration

The variety of constructs assessed during collaboration was as extensive as the disciplines and authors conducting the studies. Because the measures used were mostly observations, coding of discussions, and process-oriented data, the constructs of interest were at times less defined (due to the nature of qualitatively coding process data) than would typically be seen with self-report measures. We were surprised by the low number of before collaboration measures. Less than a fifth of the 186 studies included any before collaboration baseline measures other than basic descriptive information. Out of 186 studies, studies included only 12 instances of measuring collaborative constructs: attitudes toward collaboration, skills for collaboration, prior experience, and social networks. This indicates a large gap waiting to be addressed. For example, we did not find a single study that reported on students’ readiness to collaborate although a few did lead the students in group discussions on collaboration prior to activities (e.g. Fischer, Bruhn, Grasel, & Mandl, 2002). Shumar and Renninger (2002) point out that researchers and laypersons typically consider non-contributing individuals in a virtual environment as “lurkers” who are “shirking their social responsibility” (p. 6). Instead, the authors suggest, some of those individuals may not be ready to collaborate. The current literature, however, does not suggest a way to assess the state of collaborative readiness. Nardi (2005) begins to address this issue in her work on communicative readiness, a state in which “fruitful communication is likely” (p. 91).
constructing learning objects, user actions, search time, decision time, time on task, sharing of learning objects, sequence of tool use, navigation of tools, and social network (e.g., Chau, Zeng, Chen, Huang, & Hendriawan, 2003; Dewiyanti, Brand-Gruwel, & Jochems, 2005; Hakkarainen, 2003; Joiner & Issroff, 2003; Kester, Kirschner, van Merri, & Eumlnboer, 2005; Lipponen, Rahikainen, Lallimo, & Hakkarainen, 2003; Nokelainen, Miettinen, Kurhila, Floren, & Tirri, 2005; Rummel & Spada, 2005; Xie & Salvendy, 2003). This type of information was gathered from a variety of statistics such as (a) total time in a role, or to complete a task, make a single or a series of decisions, search for information, annotate or read, (b) frequencies of postings, emails, visited web pages, annotations, and (c) sequence information on emails, computer movements, and interactions in the software.

5.3. After collaboration

As demonstrated in Table 4, measurement and analysis after collaboration typically examined (a) changes in perceptions or attitudes towards collaborative learning, CSCL software, group efficacy, or learning in general, (b) comparison between products created by an individual versus a group, (c) comparisons between products across various supports and scaffolded contexts (e.g. role taking, problem solving, or inquiry learning), and (d) comparison between products across various CSCL tools and environments.

Studies using after collaborative measures collected and reported on three categories of information: individual differences and individual assessment of group processes, standardized testing, and after collaboration products include assignments and feedback. Individual difference measures and individual assessment of group processes, assessed via self-report questionnaires and interviews were similar to pre-intervention measures (see Table 4).

We noticed an increases focus on collaboration, including measures of task cohesion, collective efficacy, group effectiveness, and team disagreements. After collaboration products included an

| Category, type, and frequency of constructs assessed after collaboration in 186 studies |
|--------------------------------|-----------------|
| Construct                      | n               |
| Individual difference measures |                 |
| Anxiety (general)              | 1               |
| Attitude towards science       | 1               |
| Attitudes toward collaborative learning | 6 |
| Classroom community            | 2               |
| Collaborative experience       | 18              |
| Computer efficacy/or literacy  | 9               |
| Epistemological beliefs        | 2               |
| Group efficacy, satisfaction, teamwork | 7 |
| Instructional plans or beliefs | 2               |
| Interpersonal attraction in collaboration | 1 |
| Leadership abilities           | 1               |
| Learning skills, processes, styles, or approaches | 15 |
| Motivation                     | 3               |
| Social influences on collaboration | 1 |
| Social networks after collaboration | 1 |
| Standardized test              |                 |
| Cognitive tests (general)      | 1               |
| Woodcock Johnson               | 1               |
| After collaboration             |                 |
| After collaboration knowledge  | 18              |
| Assignments                    | 37              |
| GPA                            | 9               |
| Student feedback to instructors/researchers | 2 |
| Student reflections            | 3               |
| Teacher feedback to students   | 7               |
| Teacher reflections            | 5               |
| Thoughts on software           | 20              |
assortment of assignments, testing, and feedback. Most common was collaborative and individual assignments (37 studies), followed by feedback on CSCL software, content knowledge, GPA, and other feedback including feedback from the teachers to the students, student feedback to the teachers and researchers on collaborative activities, and research design (see Table 4).

6. Discussion

The purpose of this paper was to review and describe current methods of measuring CSCL. Our goal was twofold: find established measures that provide immediate and contextually relevant feedback to learners on their collaborative processes and then research and adapt those measures for use within our CSCL environment. Based on theories of self and shared regulation (Hadwin, Oshige, Gress, & Winne, this issue; Winne & Hadwin, 1998; Zimmerman, 2000) we believe learners need to be able to monitor and evaluate their solo and collaborative processes and products during actual engagement of learning. To accomplish this, they need a way to ‘see’ their processes and evaluate their products, whether those products are learning objects such as notes, search histories, and chats, or workings toward final project goals such as drafts of a collaborative paper. For example, learners need to be able to (a) identify different aspects of their learning processes, such as preparing to collaborate by reading applicable material and negotiating knowledge construction with peers, (b) monitor those processes which requires a way to record without increasing the learners to do list or cognitive load (i.e., learners should be focused on learning), (c) evaluate their processes, such as determining if the interactions are fruitful, (d) incorporate feedback generated personally (by reviewing their own behaviours) and from others, and then (e) make adaptations to their behaviours; all while engaged in the collaborative processes.

6.1. Key findings

Our review of the measures currently used in CSCL suggests a number of key findings.

6.1.1. A plethora of self-report

Much of the information known about collaborative processes and products in general (i.e. regardless of measurement timing) is gathered via the first two forms of measurement available in CSCL: self-report measures that assess the individual about the individual, and the individual about the group.

6.1.2. Findings in the field of CSCL are dominated by ‘after collaboration’ measurement

Of the three approximate times during which collaboration was assessed (before, during, and after), our review revealed just over half of the instances of measuring CSCL were administered after collaborative activity, suggesting the majority of information gained from CSCL studies (a) is measured after collaborative activity, in other words, after potential changes to an individual’s learning processes and skills have occurred, and (b) is based on the product, rather than the process, of collaboration.

6.1.3. A paucity of baseline information about collaboration and collaborative processes prior to CSCL

There were a low number of before collaboration measures, as less than a fifth of the 186 studies included any before collaboration baseline measures other than basic descriptive information. More importantly, there were only 12 instances of collaborative construct measurement before actual engagement in collaborative activity.

6.1.4. A lack of replication in CSCL studies

An extensive range of constructs were assessed in CSCL studies, perhaps as extensive as the numbers of disciplines and researchers involved. Although this highlights the many constructs associated with and important to CSCL, indicating a lack of replication and examination of reliability across various contexts and CSCL models.

6.1.5. Insufficient tools and measures for examining processes involved in CSCL

Because the measures used were mostly observations, coding of discussions, and process-oriented data, the constructs of interest were at times less defined (perhaps due to the nature of qualitatively coding process data) and coding methods and frameworks were not always shared, understandably considering the lengthy detail required for such evaluations. Unfortunately, this leads to difficulties in determining if studies were investigating similar constructs under different labels. What would be helpful is a standard metric or published set of descriptions that are transferable across studies.

6.1.6. There is an overreliance on conventional text-based measures rather than mining the potential of CSCL technologies to assess dynamic fine-grained details

As demonstrated in Table 1, the majority of measurement methods were self-report, observations, and content analysis of discussions. This highlights Hathorn and Ingram (2002) concern that the emphasis of CSCL work has been on developing, describing and experimenting with CSCL as they relate to individual outcomes, rather than exploring and examining differences in the collaborative process. For example, questionnaires and interviews generate rank or ordinal data summarizing learners’ awareness, perceptions, recollections, and biases about learning processes. This information is informative yet these methods do not necessarily provide complete or accurate views of actual learning processes (Winne & Jamieson-Noel, 2002). An evaluation of discussions and dialogues, via methods such as content analysis or social network analysis (SNA), reveal thematic dialogues and display patterns of collaboration in the forms of sociograms or graphs that represent density and centrality of communicative acts, describing the sequences and articulations of learner collaboration (Martinez et al., 2003). Also researchers can observe and code interactions between learners and interactions between learners and the computer and then graphically representation these behavioural logs, such as demonstrated by the Chronologically Ordered Dialogue and Features Used (CORDFU; Luckin, 2003). A draw back of both methods, however, is that SNA and CORDFU are analysis procedures that occur after the fact. This provides a wealth of information to future collaborative studies, methods and scaffolds but does not inform current collaborators. If we want learners to successfully self-regulate their solo and collaborative activities, we need to design activities, CSCL tools, and analysis methods that provide feedback during the process in addition to feedback after (Butler & Winne, 1995; Hadwin et al., 2005).

6.2. Potential directions for measurement in CSCL

Kreijns et al. (2003) describe constructs they consider key to successful collaboration in computer-supported environments: interdependence, interaction, individual accountability, interpersonal and small group skills, and active group processing. We believe appropriate measurement and research on these constructs requires methods that assess process in real time. As demonstrated above, the majority of measuring learning processes in CSCL is from discussions and observations. To translate the knowledge found in discussions and dialogues we need methodologies that provide the same fine-grained detailed information we receive.
from content analysis but in real time, to provide feedback to learners on their solo and collaborative learning processes while engaged in collaborative activities.

More recent methods may provide opportunities for learners to reflect during collaboration about their own collaborative activities via real-time data capturing and data analysis of detailed and accurate recordings or traces of complex cognitive processes (Chiu, Wu, & Huang, 2000; Hadwin et al., 2005; Jang, Steinfield, & Pfaff, 2002; Lippenen et al., 2003; Winne, 2006). Trace data can be collected unobtrusively so it does not interrupt cognitive processing like a think-aloud can nor does it depend on learners’ memories or perceptions (Gress & Winne, 2007; Winne, Gupta, & Nesbit, 1994). Therefore, bolstered by advances in computer technology, CSL software can now trace, in addition to facilitate, collaboration (Hadwin et al., 2005).

The future of computer-based learning for measuring learning processes lies in the development of measures that provide real-time feedback and therefore enhance student learning. In the following sections, we discuss gStudy (see Winne et al., this issue for full review) as an example of how a CSL environment can structure and scaffold learning while providing opportunities for real-time feedback and encouraging student reflection, evaluation and adaptation.

6.3. The learning kit project: gStudy as a CSL environment

In the Learning Kit project (Winne et al., 2006), our goal is to develop computer-supported learning environments and tools, such as gStudy, to facilitate individual and collaborative regulation of learning. Collaboration builds on solo learning because before a group interacts and while they collaborate, solo learning tactics provide a foundation for contributing a significant proportion of raw material – information – to collaborative enterprise. Thus, collaboration tools in gStudy are designed to meet three primary goals: (a) to help students enhance their individual self-regulation of learning as they participate in collaborative learning activities; (b) to boost each group member’s learning, development, and testing of strategies that help them collectively to collaborate better, that is, to promote shared regulation of learning; and (c) to provide methods for systematically researching the effectiveness of these tools in supporting productive individual and shared self-regulation, as well as the group’s co-regulation of their collaborative processes.

An important feature of the gStudy software is the trace data it unobtrusively collects: detailed information about students’ studying actions by logging the time and context of every learning event. Traces recorded in gStudy are artifacts of tactics and strategies in a log of fine-grained, temporally identified data that can advance research about how learners go about learning. Collecting traces of student activity in computer-supported learning environments may provide information about the dynamic, situated nature of learning, as well as individual differences in engagement (Winne et al., 1994).

gStudy provides numerous ways to trace collaborative exchange and dialogue. In studying appropriation of self-regulated learning (SRL) skills, use of discourse analysis has been the main methodology. Trace data of the dialogues that occur in chat tools and coaching will provide data about incremental change across time, both in the content of the interactions and user’s reliance of scaffolded SRL tools within gStudy, because trace data logs the conversation as well as the context of the learner. From trace data, we know when and which windows within gStudy are open, if learners change views, add information, create new links, or browse their documents. Therefore we know the state of the learners’ environment before, during, and after collaboration.

While conventional analysis methods have contributed to an understanding of mechanisms involved in a basic shift in the appropriation of SRL, gStudy provides rich and sophisticated ways to collect data about “transaction” between students and context (Corno, 2006). For example, collaboration in gStudy is facilitated in asynchronous and near synchronous1 modes. In near-synchronous mode, students engage in live text exchanges using an innovative design for a chat tool (gChat). Our chat tool moves seamlessly between (a) scaffolding each collaborator’s tactics and roles in ways research indicates make collaboration more effective and (b) integrating with our coach tools to guide students to explore and share in regulating collaborative activities to make them more effective (see Morris, Church, Hadwin, Gress, & Winne, this issue). In addition, our chat tool allows learners to ‘drag and drop’ products made in gStudy, such as notes, glossary items, and study tactics. In asynchronous mode, collaborators have multiple methods for sharing learning and its products that are created along the timeline of a collaborative project. For example, teammates can asynchronously share one kit and all its diverse, richly linked contents (notes, documents, etc.). Or, learners can share their individual kits or specific objects from their kits to a group kit, the latter providing for a highly focused collaboration in contrast to the former “complete package” that includes all collaborators’ contributions. Additionally, learners can study collaboratively outside of designated collaborative activities by sharing learning objects via kit exchange, shared kits, exporting and importing, or chat.

The gStudy collaborative environment affords learners the opportunity to give or receive modeling and feedback on their tasks. For example, in the Self-Regulation Empowerment Program (SREP) developed by Cleary and Zimmerman (2004), a tutor demonstrated and verbalized how he or she used SRL skills in studying. In gStudy, the tutor’s demonstration can be shown via the open chat, or the tutor can verbalize their skills through the chat tool to provide modeling. Further, if these SRL skills were pre-stocked in gStudy, the guided chat would function as a model for the learner. In giving feedback to the student, the open chat tool allows a teacher to give feedback to the contents that the students send.

7. Conclusions

Currently the field of CSL is dominated by analysis of processes and products to inform future collaborative activities instead of supporting current ones. We suggest tools and functions in gStudy offer new directions for research on collaborative learning. For example, via gStudy, learners can share one kit among group members facilitating collective regulation of learning or share multiple objects between kits to facilitate interdependence and self-regulation, gStudy traces allow researchers to examine the unfolding collaboration over time as groups collectively transition forward and backward through phases of self-regulated learning. Logfile traces allow researchers to track transitions between students as they adding new objects, updating old contents, and reviewing what is currently within the kit. Rather than a log representing one student’s SRL, it will represent the dynamic interactions between students and the environment (i.e., gStudy), as well as among the group members. This will provide ways to summarize and present learning processes and products to learners, providing opportunities for them to monitor, evaluate, and adapt their learning during solo and collaborative activities.

1 True synchronous collaboration requires each participant to see each character typed and each move made during collaboration. See Gress et al. (this issue) for more information on delineating synchronous and asynchronous tools.
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