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An examination of CSCL methodological practices and the influence of theoretical frameworks 2005–2009

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Abstract The goal of this research is to provide an overview of CSCL methodological practices. CSCL is a vibrant interdisciplinary research field where several different theoretical and methodological traditions converge. Given the diversity of theoretical and methodological traditions that co-exist in CSCL, it is important to document the kinds and range of methodological practices and examine how they are related to the diverse theoretical perspectives in the field. In the current study, we examined CSCL research methodology in terms of (1) research designs, (2) research settings, (3) data, and (4) analysis methods. We then examined how these dimensions are related to the theoretical frameworks of the research. A content analysis was carried out based on empirical CSCL studies published in seven leading journals of the field during 2005–2009. The analysis identified the dominant CSCL research practices. We found that the modal CSCL study used descriptive designs that were carried out in classroom settings, typically collected questionnaires and analyzed the data quantitatively. CSCL research methods, however, were also quite diverse and eclectic, as researchers used range of data collection and analysis practices. We additionally examined how theoretical frameworks influenced methodological practices. In addition, a cluster analysis examined how these practices co-varied. Four distinctive method-theory clusters emerged, each with a distinct profile. Remaining methodological challenges of the field are discussed along with suggestions to move the field toward meaningful synthesis.

Keywords CSCL · Research methodology · Content meta-analysis · Research design · Research settings · Data · Analysis methods · Theoretical framework · Multidisciplinary research

Collaboration has proven to be an effective mechanism to promote learning, especially when construction of complex knowledge is involved (Chi 2009; Rogoff 1998; Stahl 2006). When

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learners enter the work force, they often work in teams and need to communicate effectively and work productively with co-workers (Davies et al. 2011; Powell et al. 1996; The Secretary's Commission on Achieving Necessary Skills 1991). As advancements in digital technology have created rich affordances for social interaction, numerous applications have been designed and implemented to support collaborative learning, connecting remote students synchronously and/or asynchronously as well as supporting productive face-to-face collaboration. This has led to the emergence of an interdisciplinary research field of Computer-Supported Collaborative Learning (CSCL). CSCL is concerned with understanding how people learn together with the help of computers (Stahl et al. 2006). The field began in the early 1990s, continued its growth, and according to Dillenbourg et al. (2009), has entered a mature phase since 2005 in which CSCL is no longer considered a distinctive pedagogy and has been integrated within the rest of the educational environment at large.

Methodological challenges for CSCL research

The core research questions of CSCL revolve around how to understand tool-mediated collaborative learning (Suthers 2006). In CSCL, learners not only work as individuals, but also as a member of a dyad, small group, and/or larger group, such as a classroom or community. The interaction among learners may occur face-to-face, but can also occur remotely with the help of computers. Studying these interactions poses a number of challenges for researchers. CSCL research needs to deal with a large amount of interaction data generated during collaborative learning, often in the form of synchronous and asynchronous text messages. In addition, there are a variety of log data and computer records that capture who talks to whom and when, as well as various forms of co-created digital artifacts. These data sources provide rich information to understand CSCL and can be subjected to different analytic techniques and methods.

From the outset, CSCL has cut across disciplinary boundaries and attracted researchers and practitioners from such fields as psychology, education, computer science, and linguistics. They brought diverse theoretical and methodological approaches from their respective disciplines to the study of CSCL. Quantitative approaches such as surveys and experimental designs, traditionally used in the study of individual psychology, has been widely adopted in CSCL research to examine the effects of various technological innovations and pedagogical interventions. At the same time, CSCL eagerly embraced qualitative methods such as case studies, conversation analysis, and ethnographic investigations, which were motivated by the need to achieve a detailed understanding of the collaborative learning processes along with the institutional and cultural contexts of technology use (Guribye and Wasson 2002; Koschmann and LeBaron 2003; Martinez et al. 2003; Morken et al. 2007).

The synchronous and asynchronous text messages generated in many CSCL environments were initially analyzed in terms of their surface features such as number of postings or messages read and replied. However, as researchers sought to uncover underlying mechanisms of learning, they increasingly turned to analysis methods such as content analysis, verbal analysis, or discourse analysis (Jeong 2013). A number of recent papers have addressed various methodological issues associated with these analyses such as coding scheme development, segmentation, and reliability (Alpers et al. 2005; Baker et al. 2007; Beers et al. 2007; De Wever et al. 2006; Meier et al. 2007; Raffleff 2007; Rosé et al. 2008; Strijbos et al. 2006; Strijbos and Stahl 2007). Techniques such as Social Network Analysis (SNA) have been proposed as a way to analyze computer-generated log data in CSCL (De Laat et al. 2007; Dringus and Ellis 2005; Martinez et al. 2006; Romero et al. 2008). Researchers have also emphasized the need to conduct multi-level analysis because CSCL involves small groups and/or communities as well as individuals (Cress 2008; De Wever et al. 2007; Stahl 2013).

The diversity in CSCL research methodology has created a lot of excitement and has helped to generate new research ideas and analytic approaches (Suthers et al. 2013), but they also created tension in how to best approach and evaluate CSCL research (Arnseth and Ludvigsen 2006). There are debates as to what counts as valid and rigorous research (Borrego 2007; Cobb and Jackson 2008; Naidu and Jarvela 2006). Whereas some approaches emphasize objectivity and generalizability as the cornerstone of scientific research, others emphasize personal interpretations as a way to understand the phenomena. Although attempts are made to mix and combine multiple analytic techniques (Hmelo-Silver 2003; Johnson and Christensen 2008; Johnson and Onwuegbuzie 2004; Puntambekar 2013), different traditions largely co-exist in CSCL without a clear understanding of how they are related to each other. This state prevents the integration of research findings obtained using different methodological traditions and hinders the progress of the field as a whole. A first step toward better research synthesis is to understand the methodological practices we use to generate evidence.

A content meta-analysis as a way to synthesize CSCL methodological practices

In order to understand CSCL methodological practices, we need to go beyond individual methods and identify the range of methodological practices and how they are related to each other. One may resort to narrative reviews to achieve that goal, but content analysis or content meta-analysis can be used for this purpose as well. While meta-analysis is typically associated with statistical analysis aimed at examining the robustness of empirical findings across a number of studies, content meta-analysis focuses on conceptual aspects of the investigations. Content meta-analysis systematically codes features of research such as research method, theories and/or practices of applications and synthesize them across a large body of research. They are not immune to researcher biases, but it allows us to examine contents of research more systematically compared to narrative reviews.

Recently, several papers have used content meta-analysis to examine trends in research methods and research topics in fields related to CSCL (Hew et al. 2007; Hrastinski and Keller 2007; Shih et al. 2008). For example, Hrastinski and Keller (2007) have examined research approaches (e.g., empirical versus conceptual studies, quantitative or qualitative methods) of the papers published in four leading journals of educational technology between 2000 and 2004. They found that about two thirds of the studies were empirical investigations, roughly half (51 %) of which used quantitative methods, 25 % used qualitative methods, and 24 % used mixed methodologies. Hew et al. (2007) conducted a similar analysis in the field of instructional technology. They focused on empirical articles and examined research topics and methodologies based on publications in three journals during the same period (i.e., 2000 and 2004). They reported that descriptive and/or correlational studies were the dominant research methods in instructional technology used in more than half of the studies published during the same period, but research methods varied depending on research topics so that experimental methods were more commonly used in studying the topic of psychology of learning and teaching, whereas descriptive methods were most frequently used media studies that examined media usage in educational contexts.

Although the results from these meta-analyses were informative, they focused on the instructional and educational technology fields. With its research focus on collaboration and dialogue, CSCL methodologies are likely to present a somewhat different picture. In addition, prior meta-analyses tend to examine research methodology in terms of global approaches to research such as quantitative versus qualitative methods. Quantitative or qualitative methodology actually refers to a set of research practices associated with research design, data sources, research settings and analysis techniques. In order to seek a better grasp at the methodological practices (e.g., the kinds of diverse data sources and analytic techniques CSCL research rely on), we need to examine them at a more fine-grained level.

Current research

The goal of the current investigation is to examine methodological practices of empirical CSCL research. We begin this meta-review without a specific hypothesis about the strengths and weaknesses of different CSCL research practices. Our first goal is rather to understand the overall state of the field. We anticipate, however, that the content meta-analysis can reveal weaknesses and blind spots in CSCL research practices that are not clear when they are examined from the perspective of individual studies or methods. Our secondary goal is to identify the influence of theoretical framework on research methodology. Research methods rarely stand alone. Methods are closely linked to other aspects of research such as theoretical frameworks and research questions. The tensions that arises in CSCL research are largely rooted in differing theoretical frameworks and/or epistemological stances (Bryman 1984; Morrow and Brown 1994). To address them properly, we need to document and examine their influences more clearly.

This research is part of an ongoing project aimed at examining CSCL research along a number of dimensions such as research questions, outcomes, technology use as well as research methods. Preliminary findings from this project have been reported in conference proceedings (Jeong and Hmelo-Silver 2010a, b, 2011, 2012). Two earlier publications (Jeong and Hmelo-Silver 2010a, 2011), using a smaller sample, reported on the preliminary findings about CSCL research methods. The current paper extends earlier findings with additional analysis (e.g., examination of how different dimensions are related, cluster analysis of these dimensions) on a larger sample.

In the current paper, we focus on examining the methodological features of CSCL empirical papers published from 2005 to 2009. We begin our examination from 2005. It is the year where earlier reviews took off since Hew et al. (2007) and Hrastinski and Keller (2007) both covered the literature up until 2004. Although these did not target CSCL studies, there may be some similarities given that researchers often belong to multiple research communities and publish in a number of different journals. According to Dillenbourg et al. (2009), 2005 is also the year that marked the beginning of the third phase of CSCL, a mature phase in which CSCL became one of the established educational approaches. We restricted the sample between 2005 and 2009, because of a need to wrap up and reflect on the results as well as resource limitations. We acknowledge that this period is not the most current period and the results are likely to miss most recent methodological trends such as learning analytics (Long and Siemens 2011; Martin and Sherin 2013). However, the analysis should still help us gain deeper understanding about CSCL methodological practices and the influence of theoretical frameworks and help us seek better alignments among different methodological traditions.

Methods

We identified target CSCL literature from the published papers in leading journals of CSCL, following the method used in prior content meta-analysis (Hew et al. 2007; Hrastinski and

Keller 2007). In this section, we describe how we chose relevant journals and screened for empirical CSCL papers and the coding schemes used for the content meta-analysis.

Journal selection

The International Journal of Computer Supported Collaborative Learning (ijCSCL) began its publication in 2006 and serves the role of the flagship journal of the CSCL community. In addition to ijCSCL, there are numerous other research journals where CSCL research has been and continues to be published. In order to identify additional journals where CSCL research is published, we contacted leaders in the CSCL community, which included the CSCL committee of International Society of the Learning Sciences (ISLS) and the editorial board members of ijCSCL. We asked them to nominate up to five leading CSCL journals other than ijCSCL. Based on the responses from 16 leaders, we selected the following seven journals: (1) International Journal of Computer Supported Collaborative Learning (ijCSCL) (2) Journal of the Learning Sciences (JLS), (3) Learning and Instruction (LI), (4) Computers and Education (CE), (5) Journal of Computer Assisted Learning (JCAL), (6) International Journal of Artificial Intelligence in Education (ijAIinEd), and (7) Computers in Human Behavior (CHB). Our search was restricted to these seven journals to keep the review process manageable. These were all peer-reviewed journals published by well-known publishers with international author- and readership. Articles published in these journals during 2005–2009 (i.e., five years of publication and four years of publication in the case of ijCSCL) were subjected to further screening.

Paper selection

We screened papers published in the selected journals and identified empirical CSCL research papers. When we surveyed the community leaders for journal selection, we also provided them with a definition of CSCL and asked them to provide feedback. The resulting definition of CSCL was: Computer-Supported Collaborative Learning (CSCL) is an interdisciplinary research field that includes a branch of the learning sciences and educational technology research concerned with studying how people can learn together with the help of computers. Research in CSCL focuses on learning as a cognitive and/or social process and studies learning designs, learning processes, and pedagogic practices that support technology-mediated coordination, communication, and collaborative processes in communities of learners (Miyake 2006; Stahl et al. 2006).

Based on this definition, we operationalized “empirical CSCL research” in the following manner. Empirical research referred to studies that relied on empirical data to validate a theory, hypothesis, research question and/or design. Theoretical papers or papers about technology design could be included if they contained data, but excluded if they were purely about theory or design. The data had to be primary data. Studies that included secondary data analysis, simulated results, and meta-analyses were not included. This did not mean an exclusion of studies that analyzed data collected as part of a larger project. As research projects become larger and more collaborative they often collect a large amount of data, in which they may analyze and publish them over several articles. The data may have been collected as part of a larger project, some of which may have been analyzed, but the analyses and findings must be novel to have been included in our analysis. Lastly, papers should be explicit about the data collection process. The papers ranged widely in how completely they reported on the data collection and analysis process. There were papers that provided no or only loose descriptions of the research method. According to Hrastinski and Keller (2007), for example, about 13 % of the studies in their study did not have an explicit method section. We did not exclude papers with no explicit method section, but the papers needed to provide sufficient details about the method so that coding could be accomplished with minimal inferences.

CSCL research referred to studies where participants learned collaboratively while being supported by computers and/other technological tools. The applied technologies did not necessarily have to be so-called collaboration technology such as e-mails or discussion boards, but they needed to use the technology to support collaboration in some way (e.g., computer used as a co-reflection tool). The technology also needed to be specific so that studies examining the effect and/or adoption of Information Technology in general were not included. Learners needed to interact in small groups or interact with peers in some way. Students' interactions with teachers were not considered collaborative unless it occurred in the context of peer collaboration. Interactions with peer tutors or intelligent agents or systems were considered collaborative because these involve similar mechanisms (Chi et al. 2001). Learning was considered collaborative as long as learners engaged in interaction at some points during the learning process (e.g., learners collaborated after individual study period). Studies needed to address learning, but relationship to learning was broadly construed. Studies may examine learning directly but could also examine variables and processes related to collaborative learning (e.g., motivational factors related to learning). Studies about special populations (e.g., students with physical or learning disabilities) were excluded because these studies can involve special technologies not typical in CSCL.

The selection process proceeded in two stages. First, initial selection of empirical and methodological CSCL papers was conducted based on the title and abstract of the paper. At this stage, we tried to be as inclusive as possible so as not to miss any potential CSCL papers. The initial screening was verified at the coding stage when the paper was examined more comprehensively. In sum, we screened 1,999 papers and selected 400 papers for further analyses (see Appendix in Online Resource).

Content analyses

Research methods are often discussed in terms of global research approaches such as quantitative versus qualitative methods. Quantitative or qualitative method actually refers to a set of research practices associated with research design, data sources, research settings and analysis techniques. In this paper we examined research methods along the following dimensions of empirical CSCL investigations: (1) Research designs, (2) Settings, (3) Data, and (4) Analyses (see Table 1). Coding categories were developed for each dimension based on a combination of inductive and deductive approaches: They were initially generated top-down (e.g., using categories drawn from the submission descriptors of the 2005 CSCL conference) and later refined bottom-up through multiple coding iterations. Coding schemes for each coding category are described below.

Research design Research designs referred to the research plan regarding how the research questions were going to be answered. They varied depending on the study's objectives or strategies such as whether the study aimed to describe or explain. Experimental design or experiments referred to studies where researchers actively manipulated variables in order to examine causal relationships among variables (e.g., whether the use of collaboration scripts increases interaction). It is typically used in quantitative research and can be further divided

Table 1 Coding categories for research design, settings, data, and analysis

Dimensions	Categories	Descriptions
Design	Experimental	Causal relationships among variables examined by controlling variables. Subdivided into (a) randomized, (b) quasi-experimental, and (c) pre-post design.
	Descriptive	Studies seek to uncover regularities and relationships in the phenomena.
	Design-based	CSCL tools and interventions are examined in theoretically-driven ways in practice settings and refined progressively over several iterations.
Settings	Laboratory	Laboratories or other controlled settings
	Classroom	Classrooms or other educational settings lead by teachers (e.g., field trips)
	Other	Miscellaneous settings (e.g., online communities)
Data	Process	Collected in the form of (a) asynchronous text, (b) synchronous text, (c) video/audio, (d) log data, and (d) other types of data.
	Outcome	Collected in the form of (a) multiple-choice questions, (b) open-ended questions, (c) artifacts (e.g., whiteboard contents, wiki pages), and (d) other (e.g., course grades).
	Miscellaneous	Collected in the form of (a) questionnaire/self-report (e.g., motivation, perception), (b) interview or focus group, (c) field notes or observations, and (d) other (e.g., IQ tests).
Analysis techniques	Quantitative	Include (a) code and count, (b) simple descriptive, (c) inferential statistics, (d) modeling, and/or (e) other.
	Qualitative	Include (a) qualitative content analysis, (b) conversation or discourse analysis, (c) grounded theory, (d) interaction analysis, (e) miscellaneous other methods, and (f) loosely defined.

into (a) randomized (e.g., participants are randomly assigned to different conditions), (b) quasi-experimental (e.g., assignments to conditions were nonrandom as in assigning different class to different conditions), and (c) pre-post design (e.g., pretest, followed by intervention and one or more posttests; Keppel and Wickens 2004; Shadish et al. 2002; Shavelson 1996; What Works Clearninghouse 2008). Descriptive designs referred to studies that aimed at describing a phenomena or case as it occurred. These sought to uncover regularities in the data without actively manipulating variables that compared one particular CSCL intervention to another. Case studies, observational studies, surveys, correlational studies, and ethnographic investigations are all examples of descriptive design. An attempt was made to code these sub categories of descriptive design initially. However, coming up with a set of reliable features that permitted an exclusive categorization of descriptive designs into one or another category proved to be challenging (e.g., a case study could also be an observational study or action research). In addition, these designs are frequently aligned with analysis methods (e.g., interaction analysis, conversation analysis). We thus coded them all under the category of descriptive designs. Design-based research methods referred to the research strategy in which CSCL designs and interventions were investigated in theoretically-driven ways and refined progressively over several iterations (Barab and Squire 2004; Brown 1992; Sandoval 2014). To be coded as design-based method, the study not only needed to design CSCL systems or applications, but the design itself needed to be theoretically grounded, instantiated in specific contexts, and studied and refined iteratively as part of a bigger design-based research program. Note that design-based research refers to a framework or strategy of research that can transcend the design of individual iterations that may be either experimental or descriptive. Once a study was coded as design-based method, the design of individual iterations was not coded separately.

Research settings Research settings were defined as the contexts in which the research was conducted. Laboratory referred to lab-like controlled settings where data collection was carried out outside the context of classrooms or other authentic learning situations. Classroom settings referred to a more or less formal learning situation that was guided by teachers both within and outside of the physical classrooms (e.g., field trips, distance learning course). Other settings referred to CSCL settings outside laboratories or classrooms such as workplace, online communities, or informal learning environments (e.g., teacher workshops, professional conferences).

Data Data referred to the sources and materials, analysis of which provided evidence for the study. Process data referred to data sources that could reveal CSCL learning processes such as synchronous and asynchronous messages. Outcomes data referred to data sources that revealed the product or results of CSCL such as multiple-choice and open-ended test items or artifacts (e.g., diagrams drawn during collaboration). Miscellaneous data referred to data that dealt with non-cognitive and situational aspects of CSCL such as questionnaires that assessed perception and motivation of students, interviews, or field notes made by researchers (see Table 1 for sub-codes). In principle, only data for which analysis results were reported in the results were coded. However, it was not always clear which data were used in the analyses, especially in qualitative studies.

Analysis methods This category referred to the kinds of analyses carried out on the data sources and consisted of two general categories of Quantitative and Qualitative analysis, which were further divided into sub-codes (see Table 1). In the case of quantitative analyses, code and count, often called as verbal analysis or (quantitative) content analysis, referred to analyses that quantified qualitative data such as texts or dialogues. The outcome of the code and count analysis could then be subjected to inferential statistics or other more advanced quantitative analysis (Chi 1997; Jeong 2013; Neuendorf 2002). Simple descriptive referred to descriptive statistics such as frequencies or means. Inferential statistics referred to t-tests, ANOVA or regressions, whereas modeling referred to more complex analytic techniques such as log-linear analysis, Structural Equation Modeling, or multi-level analyses. Note that the last three types of quantitative analyses are hierarchically related. Modeling statistics presumes the use of inferential statistics, which also presumes the use of descriptive statistics. We thus coded the most sophisticated form of analysis among simple descriptive, inferential, and modeling. As for the code and count, if the results of code and count were subject to inferential statistics or advanced modeling, they were additionally coded. Other referred to quantitative analysis that did not belong to any of the preceding categories (e.g., Social Network Analysis).

As for qualitative analyses, (qualitative) content analysis referred to systematic text analysis that were done qualitatively (Mayring 2000). Conversation or discourse analysis referred to analyses that analyzes conversations or discourses, but can vary considerably in their approaches and techniques (Gee and Green 1998; Koschmann 2013; Sacks 1992). Grounded theory referred to qualitative analytic techniques developed by Glaser and Straus (1967) and Straus and Corbin (1990) that emphasized the discovery of theory based on the systematic analysis of data. Codes, concepts, and/or categories can be formed in the process of formulating a theory, but interpreted quite differently from the way they are used in the quantitative analysis (Glaser and Straus 1967; Straus and Corbin 1990). Interaction analysis referred to an analysis technique rooted in ethnography that relies heavily on video technology (Jordan and Henderson 1995). The Miscellaneous category referred to other established methods such as narrative analysis, thematic analysis, or phenomenography. Qualitative methods are not merely about analysis, but often refer to a whole approach to inquiry that prescribes research objective, design, data collection method as well as analysis. Boundaries of different qualitative analyses are not always clear-cut. We thus relied on author's description of their analysis method. If they named their analysis phenomenology over grounded theory or provided analytic traditions or systems (e.g., "methods from ethnography"), it was coded as such. Finally, loosely defined category referred to qualitative analyses that did not appear to be linked to any specific analytic traditions; the data were merely analyzed in qualitative ways. Analysis was coded as loosely defined when results were qualitatively described without a reference to specific analytic traditions or techniques.

Theoretical frameworks Theoretical frameworks referred to theories or conceptual framework that guided the research and had nine categories (see Table 2). Information processing theory referred to traditional cognitive theories with a strong emphasis on individual cognitive processes such as encoding and retrieval from memory (Shiffrin and Schneider 1977; Tulving and Madigan 1970). Socio-cognitive theory referred to theories related to Piagetian notion of cognitive conflicts and conceptual change (De Lisi and Golbeck 1999; Doise et al. 1975). Constructivism referred to a broad range of theoretical approaches that emphasize active learner processing and knowledge construction either in individualistic and collaborative settings (Chi 2009; von Glaserfeld 1987). Socio-cultural theory referred to a diverse range of theories such as Vygotskian approach, distributed and/or situated cognition, or activity theory that emphasizes the fundamental role of tools, activities, social norms and systems (Engeström 2001; Hutchins 1995; Salomon 1993; Vygotsky 1978). Communication theory

t2.1 **Table 2** Coding categories for theoretical frameworks

Categories	Descriptions
Information processing	Classic cognitive, with a strong emphasis on individual cognitive processes such as encoding and retrieval from memory
Socio-cognitive	Related to Piagetian notion of cognitive conflicts and conceptual change
Constructivism	Emphasize active learner processing and knowledge construction either in individualistic and collaborative settings
Socio-cultural	Emphasize the role of social support, tools and activities, and socio-historical contexts of learning and encompass theories such as distributed and/or situated cognition, or activity theory
Communication	Focus on linguistic and communicative aspects of social interaction
Social psychology	Focus on social aspects of collaboration such as status difference, gender, or group dynamics
Motivation	Focus on motivational aspects of learning addressing issues such as attribution or self-regulation
Other	Not in any of the above categories (e.g., constructionism)
A theoretical	Investigations guided by primarily practical or technical concerns.

referred to theories addressing linguistic and communicative aspects of collaboration (Krauss and Fussell 1990). Social psychology theory referred to theories that focused on social aspects of collaboration such as status difference, gender, and/or group dynamics (Levine and Thompson 1996). Motivation theory referred to theories with a focus on motivational aspects of learning addressing issues such as attribution or self-regulation (Pintrich 1999). The Other theory category referred to theories that did not fit into any of the categories that we have described (e.g., constructionism). Studies coded as Atheoretical referred to investigations that were primarily guided by practical concerns (e.g., program evaluations). Like qualitative analysis methods, boundaries of different theoretical frameworks were not always clear-cut. If authors explicitly named their theoretical frameworks, we coded them as such. If they were not, we relied on references and major variables examined in the study (e.g., conceptual change is a typical variable or topic of study strongly associated constructivism). Studies could have more than one theoretical framework.

Coding and analysis

As noted earlier, coding was carried out based on descriptions provided in the paper. If the study was described as "experimental" or "interaction analysis," we coded it that way. In a few cases where the description was controversial or inconsistent, we followed a more conventional definition, so that "near synchronous" interaction was coded as asynchronous interaction and that an "experiment" without any control condition was coded as a descriptive design. If "design research" was used merely to refer to the topic of the study (e.g., system design), such studies were not coded as designed-based. In a few cases where authors did not explicitly specify the information needed for coding, we relied on contextual information. For example, when a study did not specify data sources but stated that the number of words in asynchronous notes was analyzed, it was assumed that asynchronous text messages were collected as data (Hewitt and Brett 2007). When the study did not specify analysis method but presented a frequency table of coding categories in the result section, we assumed that code and count was used (Fuks et al. 2006). The unit of the analysis was individual papers, but multiple coding was possible when: (1) the paper contained multiple studies, (2) was conducted in more than one setting, (3) collected several different sources of data, (4) carried out multiple analyses, and/or (5) drew upon multiple more then one theoretical traditions. Three coders participated in the coding and coded different subsamples. In order to ensure coding reliability, a secondary coder independently coded a subset (20 %) of papers coded by a primary coder. Unclear cases and disagreements were discussed until they became reliable. Coding adjustments were made to reflect the discussion and elaboration of the coding schemes. Cohen's kappa values were all above .75 (.97 for research design, .94 for research setting, .87 for data, .79 for analysis methods, and .79 for theoretical framework coding).

Although the goal of this study was exploratory and descriptive, we occasionally used statistical tests to examine whether the patterns observed were reliable. Because the data were largely frequency data, we used Chi-square statistics or, alternatively, Fischer's Exact Test when cells with expected frequency below 5 exceeded 20 %. In addition, we carried out a Hierarchical Cluster Analysis (HCA) to identify whether the coded dimensions of research methods and theory tend to show patterns of co-variation. Hierarchical Cluster Analysis was used because of the exploratory nature of this work. We used the Ward's algorithm with squared Euclidian distance as a dissimilarity measure because of its proven success with dichotomous data (Finch 2005).

Results

The results section consists of five parts. First, we briefly describe the general picture of CSCL research examined in our analysis. Second, we report on the methodological practices of CSCL research along the four dimensions of research methods. We then examine the theoretical frameworks of these studies and examine how they influence the methodological practices in these studies. Finally, we present the results of the cluster analysis to look at larger patterns.

General trends in CSCL research

Excluding non-research articles (e.g., editorials, commentaries, book reviews, or obituaries), 1,999 articles were published during the 2005–2009 period in the seven journals. Among them, 400 papers (20 %) were identified as empirical CSCL investigations. Over the 5 years period, the number of CSCL investigations has been increasing, but the proportion of CSCL papers did not fluctuate greatly (see Fig. 1). The increase in CSCL publications is likely due to the general increase in published articles in the selected journals rather than a surge in CSCL investigations. At least since 2005, CSCL research took up a more or less constant proportion in these journals, suggesting that CSCL has entered a mature phase as Dillenbourg et al. (2009) have proposed.

Methodological practices in CSCL research

In this section, we report on the features of CSCL methodological practices along the dimensions of research designs, settings, data collection, and analysis methods. After reporting on the coding results of each dimension, we report on the relationships among dimensions. Because the number of possible interactions among dimensions is large, we limit our reporting to a set of particularly important interactions.

Research designs The most prevalent CSCL research design was descriptive (54 %), followed by experimental (37 %), and design-based research (9 %). There was one study that reported on both descriptive and experimental approaches (Pol et al. 2008). Although there was an Q2

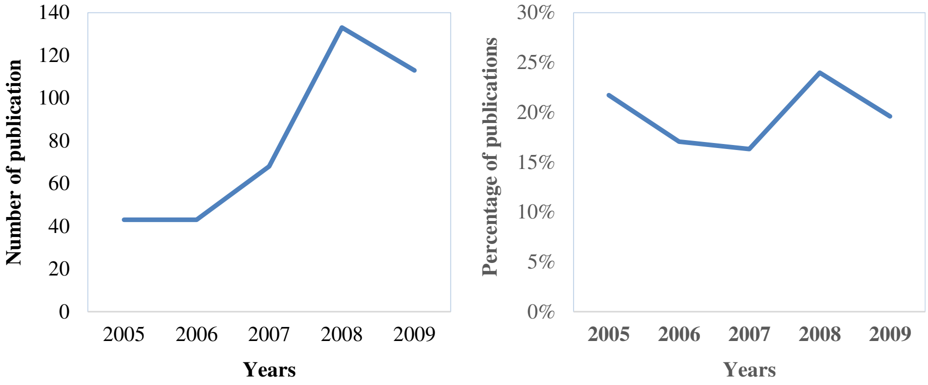


Fig. 1 The total number (*left*) and percentage (*right*) of CSCL publications in 2005–2008

increased discussion about mixed-methods, this rarely occurred at the design level. Of the experimental studies, about half (56 %) were randomized experiments, followed by quasi-experimental (33 %) and pre-post designs (12 %). As for the design-based studies, most used quasi-experiments, pre-post comparisons, and case studies approaches.

Research settings Most often, CSCL research was conducted in classrooms (74 %), followed by laboratory (19 %) and other (9 %) settings. Studies were generally carried out in a single setting, but a small proportion of studies (2 %) used multiple settings as previously reported (Jeong and Hmelo-Silver 2011). In light of the emphasis on ecological validity of education research (Brown 1992; Sandoval 2014), the wide-spread use of classroom settings is encouraging. However, it was a bit surprising to find that little CSCL research was carried out in other settings such as online communities, especially given the proliferation of online communities and the emphasis on informal or workplace learning (Barron 2006; Engeström 2001; Greenhow et al. 2009).

Traditionally, the choice of the research setting closely depended on the choice of the research design so that classroom studies would have meant descriptive studies, and lab studies typically meant experiments. Although this trend still appears to be strong, exceptions were also frequent (see Fig. 2). About a third of classroom studies were experimental, including randomized experiments (Cho and Schunn 2007; Munneke et al. 2007). Likewise, a portion of the studies adopted descriptive designs in laboratory settings, indicating that observational investigations were carried out in the laboratories. These nontraditional approaches appear to be increasing.

Data The analysis showed that CSCL research relied on a wide range of data sources (see Fig. 3). The most frequently collected process data types were asynchronous text messages (26 %) followed by log data (25 %), video/audio (22 %), synchronous text messages (18 %), and other (2 %). The most frequently collected outcome data were artifacts (23 %), followed by other (21 %), open-ended questions (15 %), and multiple-choice questions (15 %). As for the miscellaneous data, most frequently collected data types were questionnaire/self-report (57 %), interviews (29 %), field notes/observations (14 %), and other (5 %). Given the high frequency of other outcomes, we further explored what constituted this category. In addition to

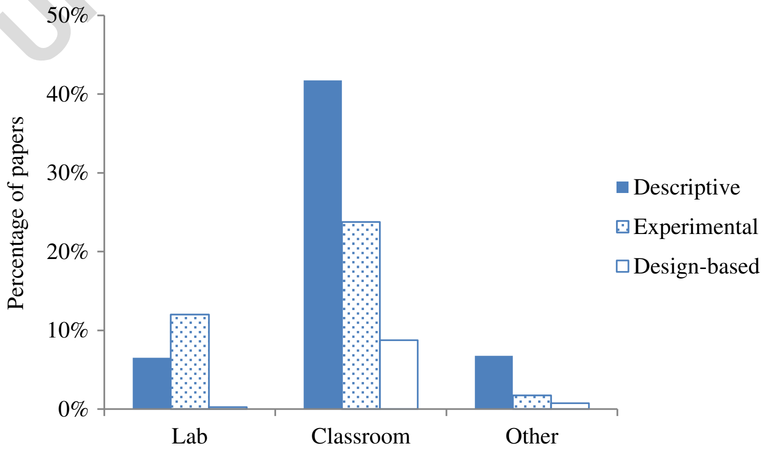
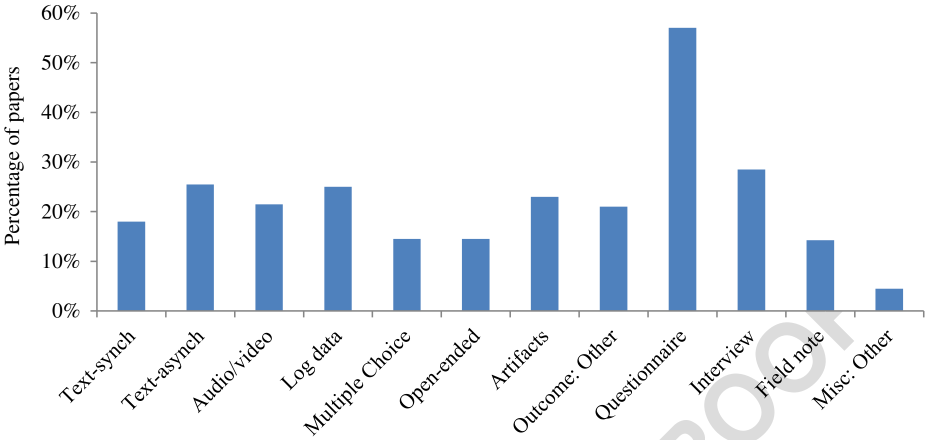


Fig. 2 CSCL research settings by design



Q3

Fig. 3 Data sources used in CSCL investigations. Note. “Process: other”, a low frequency category, was deleted from the Figure to enhance the readability

course-related outcomes (e.g., grade, failure rate), it included unconventional outcome data such as stimulated recall and solution time. A number of studies also examined peer reviewing systems and collected peer feedback and comments on each other’s work as an outcome measure.

Overall, outcome data were collected in 56 % of the studies, process data in 66 % of the studies, and miscellaneous data in 73 % of the studies. Miscellaneous data category included data types that examined non-cognitive aspects of learning as well as contextual factors of CSCL (e.g., engagement and motivation measures, interviews, and field observations). The prevalence of miscellaneous category suggests that although understanding learning processes and outcomes are still important, CSCL research is more focused on issues that go beyond traditional learning outcomes and processes. Moreover, CSCL research has been more focused on understanding learning processes over outcomes. These processes were generally studied using textual data rather than video/audio data or log data, most frequently using asynchronous communication. Learning outcomes were more likely to be studied with artifacts rather than tests. One question for further study is the reliability of these artifacts as assessment devices.

Multiple data types were collected in many investigations with the average number of data types being 2.70 per study. We examined how often each data source was collected by itself or together with other data (see Table 3). Only a small portion of articles (19 %) relied on a single data source, 39 % of which was questionnaire data. We also examined typical data triplets for each data source and found that questionnaire data were used extensively as a complementary data source as well. The number of data collection did not vary much across study settings, F (2, 389)=1.48, p>.05, but did differ across research designs, F (2, 396)=4.64, p<.05.[1] Design-based research studies collected the most different types of data (M=3.32), followed by experimental (M=2.69) and descriptive (M=2.59) studies. Design-based method emphasizes the complexity of learning environments. Studies that adopted a design-based research approach need to collect more diverse types of data to characterize the situation in all its complexity. Figure 4 also shows how data collection was influenced by research designs. Process and miscellaneous data were more likely to be collected in descriptive studies, but outcome data were used more in experimental studies.

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[1] Studies that used more than one design (N=1) or research settings (s=8) were excluded from the analysis.

Table 3 Co-occurrence of data sources and common data triplets

	Alone	Together	1	2
Text-asynchronous	9	63	Questionnaire (31)	Log data (23)
Text-synchronous	9	93	Questionnaire (48)	Artifacts (31)
Audio/video	6	80	Questionnaire (34)	Interview (29)
Log	3	97	Questionnaire (55)	Text-asynch & Artifacts (28)
Other: Process	1	8	Questionnaire (4)	Interview & Log (3)
Multiple-Choice Q	2	56	Questionnaire (39)	Open-ended (23)
Open-ended Q	1	57	Questionnaire (29)	Multiple-choice (23)
Artifacts	4	88	Questionnaire (44)	Interview (32)
Other: Outcome	7	77	Questionnaire (54)	Log data (18)
Questionnaire	30	198	Interview (68)	Log data (55)
Interview	3	111	Questionnaire (68)	Field notes (40)
Field notes	1	56	Interview (40)	Audio/video & Questionnaire (27)
Other: Misc	0	18	Questionnaire (12)	Other: Outcome (12)

Analysis methods Overall, 86 % of the studies conducted quantitative analyses and 52 % of the studies carried out qualitative analyses. As Fig. 5 shows, the most widely used analysis method was inferential statistics, being used in more than half of the studies (56 %). The next most common technique was code and count (37 %), followed by loosely defined qualitative analyses (30 %). When researchers used quantitative analysis, it generally meant the use of inferential statistics ranging from simple t-tests to more sophisticated analyses (i.e., advanced inferential statistics and modeling category). As for code and count, as we explained earlier, we treated code and count as a form of quantitative analysis because it involves an attempt to quantify qualitative data. However, code and count has been also used in qualitative traditions such as Grounded Theory. In order to separate the influence of different traditions involving the use of code and count, we examined how the results of code and count were further treated. Of the studies that used code and count analysis, 68 % used inferential statistics or modeling techniques. It is not clear, however, whether the lack of statistical testing was due to small sample sizes or purely descriptive analytic goals.

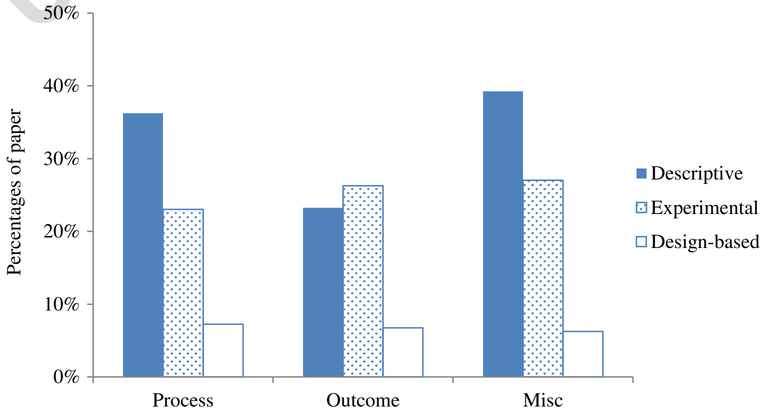

Fig. 4 Data types by research design

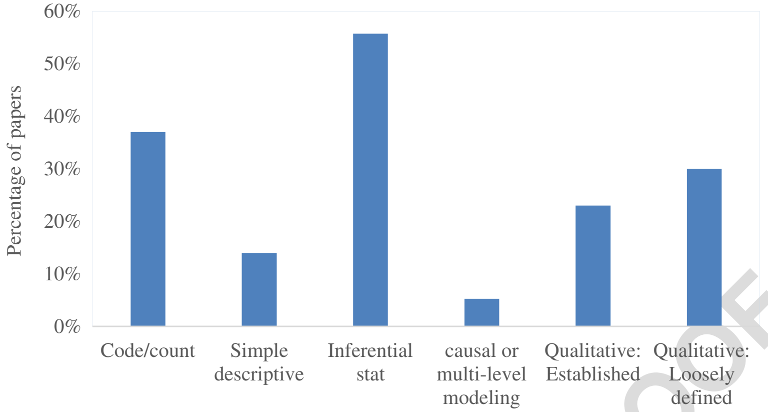

Fig. 5 Analysis methods used in CSCL investigations. Note. Quantitative: other, a low frequency category, was dropped and established qualitative methods were collaborated collapsed into one category

Q3

Despite the predominance of quantitative analyses, qualitative analyses were also frequently used in more than half of the studies. This was the case even though we included code and count in the quantitative analysis category. The use of established techniques accounted for 23 % of the analyses. The breakdown of established qualitative techniques shows qualitative content analysis (6 %), conversation/discourse analysis (5 %), grounded theory (5 %), interaction analysis (3 %), and other miscellaneous techniques (7 %) such as narrative analysis (Yukawa 2006), framework technique (Lim and Barnes 2005), phenomenographic method (Ellis et al. 2006), or thematic analysis (Robertson and Howells 2008). Qualitative analysis was conducted more frequently in a loosely defined fashion (30 %). The manner and rigor of this “loosely defined” analysis varied widely. Some studies adopted it as a way to complement statistical analysis and used it as a tool to explore the nature of the quantitative differences they observed (Lee et al. 2006; Schwarz and Glassner 2007). These often provided verbatim examples of students’ open-ended comments or answers to support the researchers’ observations and/or conclusions (Blin and Munro 2008; Markett et al. 2006; Schmid 2008). Another form of loosely defined qualitative analysis consisted of a qualitative summary of the data, which was often accompanied by simple descriptive statistics (Jacobs and McFarlane 2005; Rick and Guzdial 2006). It is unclear why loosely defined took up such a large proportion of qualitative analysis, but it is not ideal if it means a proliferation of unsystematic analysis that lack the methodological rigor of established methods.

We next sought to explore the prevalence of mixed analysis. About half of the studies (49 %) relied exclusively on quantitative analysis, 14 % relied exclusively on qualitative analysis, and 37 % used mixed analyses. As Table 4 demonstrates, the most typical mixing was between loosely defined methods on the qualitative side and code and count and/or inferential statistics on the quantitative side. Mixed methods were mostly used as a way to complement quantitative analysis, and loosely defined was the qualitative analysis method of choice in mixed analysis.

The use of specific analysis methods was associated with particular research designs (see Fig. 6). When the goal of the study was to describe the phenomena (i.e., descriptive design), qualitative analysis was more likely to be used. On the other hand, when the goal was to explain the causal mechanisms among variables (i.e., experiment), quantitative analysis were more likely to be used. Design-based research tended to rely on qualitative and mixed method approaches. Study design, however, by no means constrained the analysis method such that

Table 4 Combinations of quantitative and qualitative analysis methods in mixed analysis

	Descriptive	Code	Inferential	Modeling	Other	Total
Content A	4	10	8	1	0	19
CA/DA	2	5	3	0	1	11
Grounded T	2	3	8	0	0	3
Interaction A	0	3	0	0	0	3
Other	5	10	10	1	0	19
Loosely D	19	54	58	0	1	97
Total	30	82	82	2	2	

Content A content analysis, *A/DA* conversation analysis and discourse analysis, *Grounded* grounded theory, *Interaction A* interaction analysis, *Other* other established methods, *Loosely D* loosely defined analysis

phenomena were often described quantitatively as well as qualitatively, and experimental studies often employed mixed method analyses as well.

Theoretical frameworks adopted in CSCL research

CSCL research was guided by a number of different theoretical frameworks as shown in Fig. 7. The most common framework was constructivism (33 %), followed by socio-cultural theories (25 %), social psychology (15 %), other (13 %), information processing (11 %), communication (7 %), motivation (6 %), atheoretical (6 %), and socio-cognitive theories (4 %). Other theoretical frameworks included approaches such as constructionism (McCarthy et al. 2005), objectivism (Yang and Liu 2007) and social exchange theory (Hummel et al. 2005), indicating that CSCL researchers were drawing from diverse theoretical foundations.

A portion of the papers (18 %) drew from multiple theoretical frameworks. For example, there were 132 studies that adopted constructivism, of which 36 studies (27 %) also mentioned additional conceptual frameworks. Further analysis showed that when theories co-occurred, it was most frequently with constructivist and socio-cultural frameworks (Table 5). These two

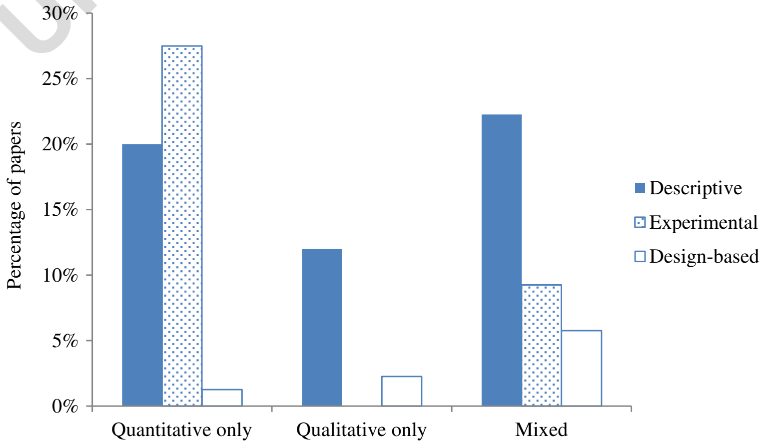

Fig. 6 CSCL research design by analysis methods

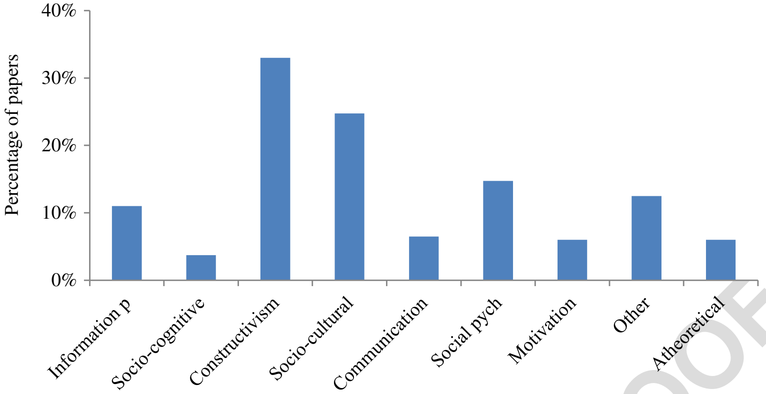

Fig. 7 Theoretical frameworks guiding CSCL empirical investigations

frameworks served to bridge diverse theoretical perspective in CSCL research. Social psychology theory, although it was the third most common theoretical framework, was generally used alone. It is unclear what causes such reliance on multiple theoretical frameworks, but there may be more synergy between some combinations than others. It may also be a result of collaboration among researchers from different disciplines with different theoretical orientations, which is frequent in a multidisciplinary field like CSCL. It can also result from a synthesis effort on the part of the researchers as they encounter different research traditions along their career.

Influence of theoretical frameworks on research methodologies

No research method is completely independent from the theoretical frameworks in which the research is embedded. Indeed, our analysis shows that theoretical frameworks have a strong influence on all aspects of research methods in CSCL. First, theoretical frameworks influence research designs so that the use of specific research designs varied across theoretical frameworks (see Table 6). The influence of theoretical frameworks on research design was significant for information processing, χ^2 (2)=6.87, $p<.05$ and socio-cultural, χ^2 (2)=15.61, $p<.001$. Information processing framework adopted more experimental designs whereas socio-cultural frameworks adopted more descriptive design.

Theoretical frameworks similarly influenced research settings and data collection. Compared with other frameworks, classroom settings were more likely to be used with constructivism (35 %) and socio-cultural framework (24 %). Laboratory settings were likely to be used with constructivism (33 %) and information processing and social psychology frameworks (21 % each). Other settings were more likely to be used by socio-cultural (50 %) and other frameworks (27 %) Theoretical frameworks also influenced data collection. Studies framed in constructivism collected more outcome data (69 %), whereas socio-cultural studies collected more process data (83 %). In addition, motivational frameworks collected more miscellaneous data such as questionnaire or interviews (92 %).

Lastly, analysis method varied depending on the theoretical frameworks of the study (Table 7). For example, information processing and social psychology frameworks tended to use more quantitative, but less qualitative and mixed analyses. In contrast, socio-cultural

Table 5 Co-occurrence of theoretical frameworks

	Information processing	Socio-cognitive	Constructivism	Socio-cultural	Communication	Social psychology	Motivation	Other
Single	30 (68 %)	4 (27 %)	96 (73 %)	72 (73 %)	14 (54 %)	42 (71 %)	14 (58 %)	34 (68 %)
Multiple	14 (32 %)	11 (73 %)	36 (27 %)	27 (27 %)	12 (46 %)	17 (29 %)	10 (42 %)	16 (32 %)
Socio-cognitive	0							
Constructivism	8	5						
Socio-cultural	1	4	8					
Communication	1	0	6	1				
Social psychology	1	1	5	5	4			
Motivation	2	1	2	2	1	2		
Other	1	1	4	8	0	1	1	

Frequencies in the lower half of the table do not always add up to the cases of multiple frameworks in the top half of the table because a few studies adopted more than two frameworks

Table 6 Research designs and theoretical frameworks. Mixed designs (n=1) are omitted

	Descriptive	Experimental	Design-based
Information Pro. (N=44)a	17 (39 %)	24 (55 %)	3 (7 %)
Socio-cognitive (N=15)	5 (33 %)	8 (53 %)	2 (13 %)
Constructivism (N=131)	65 (50 %)	51 (39 %)	14 (11 %)
Socio-cultural (N=99)[a]	63 (64 %)	21 (21 %)	15 (15 %)
Communication (N=26)	11 (42 %)	13 (50 %)	2 (8 %)
Social Psychology (N=59)	32 (54 %)	26 (44 %)	1 (2 %)
Motivation (N=24)	12 (50 %)	11 (46 %)	1 (4 %)
Other (N=50)	28 (56 %)	17 (34 %)	5 (10 %)
Atheoretical (N=24)	17 (71 %)	7 (29 %)	0 (0 %)

[a] indicates statistical significance

research tended to use less quantitative techniques, but more qualitative and mixed analysis methods. Theoretical frameworks significantly influenced analysis methods in information processing, χ^2 (2)=29.06, p<001, socio-cultural, χ^2 (2)=54.18, p<001, social psychology, χ^2 (2)=16.86, p<001, and other frameworks, χ^2 (2)=9.13, p<01.

Four methodological clusters

Given the complexity and diversity of current methodological practices and their alignment with theoretical frameworks, we need a more sophisticated analysis that identifies co-occurring dimensions. In order to examine how different method-theory dimensions examined in this study are aligned with each other, we carried out a Hierarchical Cluster Analysis (HCA) with all methodological and theoretical dimensions. Given the emergent nature of the analysis, instead of relying on an a priori number of clusters, we relied on visual dendogram inspection as well as two forms of post-estimation. Both the dendogram and pseudo-F index (Calinski and Harabasz 1974) suggested four clusters, with F dropping off at five clusters. The pseudo T^2 showed a slight increase, which supports four clusters, but a more marked increase

Table 7 Analysis methods and theoretical frameworks

	Quantitative only	Qualitative only	Mixed
Information Pro. (N=44)[a]	38 (86 %)	0 (0 %)	6 (14 %)
Socio-cognitive (N=15)	7 (47 %)	3 (20 %)	5 (33 %)
Constructivism (N=132)	67 (51 %)	12 (9 %)	53 (40 %)
Socio-cultural (N=99)[a]	22 (22 %)	33 (33 %)	44 (44 %)
Communication (N=26)	11 (42 %)	1 (4 %)	14 (54 %)
Social psychology (N=59)[a]	43 (73 %)	3 (5 %)	13 (22 %)
Motivation (N=24)	12 (50 %)	0 (0 %)	12 (50 %)
Other (N=50)[a]	22 (44 %)	14 (28 %)	14 (28 %)
Atheoretical (N=24)	9 (38 %)	3 (13 %)	12 (50 %)

[a] indicates statistical significance

suggesting six. As advocated by Everitt et al. (2011), we avoided any one approach to selecting a number of clusters and finally decided on four clusters.

The HCA sorted 400 papers into four clusters. Eighty-eight studies (22 %) were classified into Cluster 1, 178 studies (45 %) were classified into Cluster 2, 74 studies (19 %) were classified into Cluster 3, and 60 studies (15 %) were classified into Cluster 4. Table 8 shows the core methodological dimensions of each cluster. The number represents the ratio of the studies that had the dimension present. Dimensions above .40 means that 40 % or more of the cluster had the dimension present and are considered as core dimensions. Please note that cluster membership is determined based on the distance to other members in the cluster. Not all members of the cluster may possess the same core features of the cluster.

We named the four clusters based on the core features of each cluster. Two clusters of studies were strongly associated with specific theoretical frameworks. Socio-cultural descriptive classroom studies with qualitative analysis (Cluster 1), shortened as socio-cultural classroom studies, is characterized as classroom studies with socio-cultural framework (e.g., Ares 2008; Berge and Fjuk 2006). Studies in this cluster tended to rely on descriptive design, but, unlike other clusters, rely on less-structured data sources such as audio-video, artifacts, or interviews. This cluster also tended to be associated with qualitative analyses, loosely defined analysis in particular. Constructivist quasi-experimental classroom studies with quantitative analysis (Cluster 3), shortened as constructivist classroom studies, can be characterized as classroom studies with constructivist frameworks (e.g., Dori and Belcher 2005; Van Drie et al. 2005). Studies in this cluster tended to use quasi-experimental design and rely on inferential statistics. Unlike these two clusters, the next two clusters were more eclectic in terms of the theoretical frameworks adopted. Nonetheless they showed distinctive methodological profiles. Descriptive classroom studies with questionnaire data (Cluster 2), shortened as eclectic descriptive studies, can be characterized as classroom studies with a descriptive goal (e.g.,

Table 8 Four emerging CSCL method clusters and ratios of studies in core dimensions

		Socio-cultural classroom (N=88)	Eclectic descriptive (N=178)	Constructivist classroom (N=74)	Eclectic experimental (N=60)
Design	Descriptive	0.545	0.927	0.000	0.033
	Random exp	0.000	0.011	0.378	0.817
	Quasi exp	0.080	0.006	0.541	0.083
Setting	Lab	0.000	0.135	0.027	0.817
	Classroom	0.989	0.719	0.973	0.150
Data	Audio-video	0.500	0.135	0.095	0.183
	Log	0.227	0.264	0.122	0.400
	Artifacts	0.455	0.202	0.081	0.167
	Questionnaire	0.307	0.596	0.770	0.633
	Interview	0.534	0.298	0.122	0.083
Quant	Code/count	0.375	0.354	0.311	0.483
	Inferential	0.375	0.393	0.851	0.950
Qual	Loosely D	0.489	0.287	0.203	0.183
Theory	Constructivist	0.239	0.343	0.405	0.333
	Socio-cultural	0.625	0.163	0.068	0.167

Ratios above .40 are underlined. Only dimensions with at least one ratio above .40 are shown (*Random exp* randomized experiment, *Quasi exp* quasi experiment, *Quant* quantitative analysis, *Qual* qualitative analysis, *Loosely D* loosely defined)

Van der Meij et al. 2005; Yukawa 2006). Other than questionnaire data, they did not show strong preference for specific data sources or analysis methods. Lastly, eclectic laboratory experimental studies with quantitative analysis (Cluster 4), shortened as eclectic experimental studies, can be characterized as studies that rely on randomized experiments in the laboratory (e.g., Jermann and Dillenbourg 2008; Rummel and Spada 2005). Unlike quasi-experiments often carried out in classroom settings, studies in this cluster tended to be in controlled laboratory settings with randomization of participants to different treatment conditions. These also tended to collect numeric data such as log data and questionnaires or to engage in analysis that involves quantifying qualitative data (e.g., code and count). Studies in this cluster relied heavily on inferential statistics. In sum, HCA revealed that CSCL research methods consist of four distinctive method-theory clusters each with a distinctive profile. The profiles of the clusters are quite complex, not only regarding study design, but also with respect to settings, data sources, and analysis methods. Not all clusters show a strong association with particular theoretical frameworks, but two clusters were strongly associated with specific theories, suggesting a strong alignment between theoretical and methodological frameworks.

Discussion

In this study, we presented a detailed picture of the current methodological practices in CSCL investigations. In spite of the call for randomized experimentation in educational research (National Research Council 2002), descriptive research remains the dominant research design in CSCL. Although a substantial proportion of studies were coded as experimental, only about half of them were true randomized experiments; others included quasi-experimental and single group pre-post designs. This makes sense considering the emphasis on classroom research, which makes randomized experiments more challenging. Many researchers argued against laboratory experimentation for lack of validity, and a substantial portion of the studies is now conducted in ecologically valid setting of the classroom. Given the (hopefully) innovative nature of CSCL technology and pedagogies, we are at a stage of research where, like in early stages of clinical trials in medicine, we are still trying to understand if and how CSCL achieves its effects. As the field matures, its research objectives and goals are likely to change along with research methodology. The need to improve our designs of educational intervention has led to the adoption of design-based research. Although comprising a minority of studies, design-based research has gained a respectable footing in CSCL research. It took up a sizable portion of the studies in CSCL research and it also showed a distinctive profile in terms of data collection and analysis. Because design-based research outcomes may appear across multiple articles, it may have been underrepresented here. During the years reviewed, little CSCL research was conducted in out-of-school settings such as virtual online communities.

The current study identified a diverse range of data sources used to provide evidence in CSCL research. Nonetheless, CSCL research demonstrated considerable reliance on questionnaire data, both alone and in combination with other sources. These other sources ranged from synchronous and asynchronous text messages, artifacts, and interviews, some of which were once considered unconventional. CSCL researchers typically collect and analyze multiple data sources in order to examine CSCL from multiple perspectives and seek converging evidence to triangulate findings. Analytically, CSCL research relied heavily on quantitative methods. Qualitative analysis methods were used quite frequently as well, but it was most commonly in conjunction with quantitative analysis. Purely qualitative analysis was rather infrequent contrary to our expectations at the outset. In addition, the use of established qualitative methods was relatively rare. It is not clear if this lack of precision is related to methodological rigor or limited journal space needed for the description of these methods. The increasing availability of online supplements should allow archiving of more complete methodological descriptions in the future. Alternatively, many of these looser definitions of qualitative methods may not have been intended as a real qualitative analysis, which may not always be in accord with the epistemological stances of more established and rigorous qualitative methods.

How do the results obtained in this study compare with the results reported in earlier content meta-analyses (Hew et al. 2007; Hrastinski and Keller 2007)? Although the coding schemes are different, we compared results when there were comparable codes. Research designs remain similar except for the small increase in design-based research in our sample. We found an increased reliance on questionnaires, interviews, and observation in our sample compared with the earlier research. This could be due to the differences in coding procedures (e.g., we allowed multiple coding), or it could also mean that there is an increasing trend for studies to collect more different types of data. Ease of data collection in digital form and/or attempts to triangulate evidence could also likely have played a role. The increase in design-based research may also have played a small role here as these studies tended to collect multiple forms of data trying to describe mediating processes along with outcomes (Sandoval 2014). Although analytic methods were harder to compare, the proportion of quantitative analysis remained similar, but there was more mixed-analysis and less qualitative analysis in our sample. How much of these differences are due to the differences in time or discipline is not clear and is left for future research that looks at trends across time more systematically.

One of the distinctive contributions of this paper is that this study systematically documented the influence of theoretical frameworks on research methods. Although theoretical frameworks did not completely determine research methods, they clearly had an influence, showing different predilections for research designs, settings, data, and analysis methods. This was most clearly demonstrated in the cluster analysis. The HCA provided suggestions how all these methodological and theoretical dimensions were aligned with each other. Four method-theory clusters emerged. Two of them, socio-cultural classroom and constructivist classroom, were associated with specific theoretical frameworks, but the rest were not. This suggests that research methods are not always guided by strong theoretical commitments, at least at the level of the theories examined in this study. Regardless of how strongly they were guided by theories, the four clusters showed different preferences for the various dimensions of research method. For example, the constructivist classroom and eclectic experimental studies were both associated with experimental design, but one was associated with quasi-experiments in the classroom and another was with randomized experimentation in the laboratories. Socio-cultural classroom and eclectic descriptive studies were both associated with descriptive designs in the classroom, but differed in the kinds of data sources and analysis methods used. The results of the cluster analysis are tentative and require further validation. However, the results showed that the certain dimensions of research methods tend to be aligned together and that theoretical frameworks often play a strong role.

Limitations of the study

There are a number of factors that might have influenced the outcome of the current investigation. First, in order to locate target research, we adopted a journal-based selection strategy that was used in prior meta-reviews (Hew et al. 2007; Hrastinski and Keller 2007). This journal-based selection strategy was useful in locating research that community insiders value highly, but it could be limiting as well because it may not represent CSCL research published in other journals. An alternative method would have been to select target research based on a database search, a method frequently used in statistical meta-analysis. The advantage of a database search is that it can capture more diverse literature including grey literatures (Cooper et al. 2009). Capturing diverse literature is very important in statistical meta-analysis. Otherwise, the results might be biased toward overestimating the effect sizes of target variables and treatments. However, the goal of the current study was not to examine effect sizes, but to examine research practices. Given such an objective, we do not believe that the selection method would make a difference, but, nonetheless, we acknowledge that limitation. Wider coverage of journals and studies might produce a somewhat different picture of the CSCL methodological practices.

Second, we used content analysis as a tool for synthesizing CSCL research methods. Although the use of content analysis allowed a systematic examination of CSCL methodology and produced quantitative outcomes, the results of the outcome might have been different if qualitative methods were used to characterize the CSCL research method. Lastly, although we tried to be comprehensive in our examination of research methods, the current investigation is still limited in scope. Research methods do not exist in a vacuum. It exists in the context of specific research that is driven by specific research questions as well as theoretical motivations. Ideally, examination of research methods should be carried out in connection to all these factors. Due to the limitations in resources and space, we were only able to present results in association with the theoretical framework. We are continuing our examination of research in relation to research questions and research outcomes. That analysis is ongoing.

Remaining methodological challenges of CSCL research

Despite the excitement generated by the infusion of diverse methodological traditions, there are a number of areas that require further attention in CSCL methodological practices. They are not necessarily weaknesses, rather they are remaining methodological challenges the field needs to address in order to grow and have a deeper impact. Our remaining discussion goes beyond our results to consider broader implications for CSCL research. First, the problem of shallow and haphazard application of research methods is widespread. For example, in the case of design-based research, there seems to be a conceptual confusion as to what design-based research is. It is understandable given its relatively recent introduction to the field. However, “design-based research” as a research methodology should not be confused with “design-research” or “educational design research” that are commonly adopted by researchers in the design of systems/environments whose objective is at the design of educational technology and interventions (Plomp and Nieveen 2007). Design-based research as a research method is still in the process of being developed, with the criteria for rigor still needing to be codified. It remains to be seen whether it can really deliver what it promises (Anderson and Shattuck 2012). The field needs well-delineated standards for high quality design research as well as well-developed analytic frameworks to form the basis for justifying claims (Kelly 2004; Shavelson et al. 2003). Another example of haphazard use of methods is in the wide usage of loosely defined qualitative analysis. Although qualitative analyses were widely used, the use of well-established qualitative methods was not well represented in the current sample of papers. Researchers might have simply failed to attribute their analyses to specific traditions or it could have resulted from researchers’ eagerness to apply mixed-methods. Our results indicated that loosely defined analysis was the method of choice when quantitative analysis was combined with qualitative analysis. In such cases, researchers who were trained in quantitative traditions may not be well versed in qualitative analysis. This provides an opportunity for collaboration among CSCL scholars with diverse methodological expertise.

Second, CSCL needs to develop a larger repertoire of analytic strategies and tools to deal with the large amount of diverse data collected in CSCL settings, which can come in the form of content data such as synchronous and asynchronous messages, log data, and other types of online artifacts (e.g., images, games). As the results of the current study demonstrated, much of the field's analytic efforts has been directed toward analyzing content data in the form of code and count (Baker et al. 2007; De Wever et al. 2006). Although code and count analyses can help us deal with qualitative content data more systematically, they are time-consuming and ill suited for large-scale analyses. Efforts are needed to systematize and assist with these analytic techniques so that they can be carried out more effectively without compromising analytic integrity. Automating the process of coding and counting is being explored (Erkens and Janssen 2008; Rosé et al. 2008; Howley et al. 2013). The field needs to explore additional ways to analyze these data more efficiently and meaningfully. As a field, CSCL needs to pay more attention to all types of digital data. As we have seen in the current analysis, these are abundantly collected in CSCL research, but there are few well defined techniques to deal with the large amounts of digital data. The learning analytics movement may also hold some promising directions (Long and Siemens 2011), but these efforts are at an early stage of development; more concerted efforts are needed to productively harness these data sources for meaningful research outcomes. A recent special issue in the Journal of the Learning Sciences (Martin and Sherin 2013) shows some of the promise of these techniques in CSCL.

In addition to the sheer quantity and diversity, the data collected in CSCL research are quite complex. They are often multi-modal and multi-level, encompassing different outcomes and processes. Individual and group processes co-exist, all the while interacting with the collective outcome and processes (Stahl 2013), which often need to be examined at multiple time scales (minutes and, in some cases, months and years). Indeed, a "frantic oscillation" of methodological perspectives are needed in order to deal with such data, as researchers continually shift among and reflexively relate multiple time scales, perspectives, phenomena and sources of evidence (Barab and Kirshner 2001). Coordinating and managing this process is an extremely difficult task, requiring both technical and conceptual tools. We can begin by thinking about how these complex data can be collected, stored, managed, and analyzed better. Tools such as Tatiana (Dyke et al. 2009) aims to assist multi-modal analysis and help researchers in managing, synchronizing, visualizing, and analyzing their data. More efforts are needed to develop and share such methodological tools.

Finally, we need to come up with a more sophisticated way to mix different research traditions. As we have seen in this study, "mixed-" or "multi-" method approaches are widely practiced in CSCL as a way to reconcile and combine different methodological traditions. The most common form of mixing is at the level of analysis in the form of complementing quantitative analysis with loosely defined qualitative analysis. In dealing with mixed-method research, one of critical issue is the differing epistemological assumptions of different analytical techniques (Morrow and Brown 1994; Yanchar and Williams 2006). These epistemological issues may not be present in all forms of mixed-method research, but it is unclear when it is less problematic. In addition, there appears to be different approaches and goals for mixing methods (Johnson and Christensen 2008; Martinez et al. 2006; Puntambekar 2013; Suthers et al. 2013). Some mix analyses methods, while others mix data sources. Some use different methods in a complementary fashion so that different analysis methods are often applied to different data sources. Alternatively, methods can be mixed in such a way that different analysis methods are applied to identical data sources. A recent volume on productive multivocality in CSCL is one approach to bringing synergy among different theoretical, methodological, and analytical traditions (Suthers et al. 2013). There is a need for more diverse analytic efforts and experimentations.

Moving toward a meaningful synthesis

The methodological diversity in CSCL research is exciting, but it needs to contribute to an accumulation and synthesis of knowledge. It is unclear, however, whether this is happening. Different methodologies co-exist in CSCL, but studies from different methodological traditions often remain disjointed. Discussions between qualitative and quantitative research are often incommensurable (Arnseth and Ludvigsen 2006; Cobb and Jackson 2008). We need to go beyond co-existence toward synthesis. To achieve any kind of synthesis, especially in a multidisciplinary field like CSCL, we need to do a better job at reconciling different methodological traditions. Greeno (2006) once called for integration of research methodology from different research traditions such as cognitive science and interactional approaches. Although such common ground may not be possible, or even desirable, it is essential to understand the kinds of knowledge that can be generated by different methods and what the standards of evidence are in each method. A first step is to develop awareness and knowledge about different research traditions. Translation and synthesis across disciplinary boundaries is not possible without a deep understanding of different methodological perspectives and traditions (Sung et al. 2012). Although researchers cannot be versed in all traditions, they need to be aware enough of other practices to allow meaningful communication. Knowing a method means understanding associated theoretical and epistemological commitments as well as the details of the methods. As our results demonstrate, theoretical frameworks influence all aspects of research methodologies.

Second, we need a more sophisticated and comprehensive framework to map the different research traditions and practices. Doing so requires identifying dimensions in which existing methods diverge and/or converge. It also means making hidden assumptions explicit. The current study attempted to do that to some extent with the coding of four method dimensions, but additional dimensions may need to be identified. For example, in the traditional research methodology framework, especially in the logico-deductive tradition, the researcher's role was restricted to that of an objective, passive observer. However, qualitative research in general acknowledges that the researcher is part of the environment being studied. Researchers are also considered as an analytic tool, that is, part of the meaning-making process whose perspectives and inferences will inevitably influence the interpretations and conclusions of the studies. Action research goes one step further and views researchers as an agent of change in the real world (Chen and Hirschheim 2004; Swinglehurst et al. 2008). In addition, traditions also differ in terms of how prescriptive and/or comprehensive they are. Certain approaches such as content analysis or verbal data analysis do not prescribe data collection methods, but other methods such as conversation analysis do. Qualitative methods such as conversation analysis or grounded theory are not merely about analysis, but rather about a whole approach to inquiry. Developing a more comprehensive and sophisticated framework would help us achieve better methodological alignment and integration.

Finally, we need to understand how research methods are related to other aspects of research, especially research questions and outcomes. Are there different methods used to answer different research questions that occupy different parts of the CSCL research universe? What are the areas of research where each method has been the most and least productive? Or, do different research traditions address the same question, but produce incompatible outcomes? If so, how should they be reconciled? Does adoption of certain methodology obscure certain aspects of the phenomena while increasing sensitivity to other aspects? These questions are difficult to address, but answering them is necessary in order to make progress toward synthesizing a coherent body of knowledge that connects findings from different research traditions. In any field, methodology is of utmost importance because it dictates how researchers produce and validate knowledge claims. It is through rigorous application of appropriate research methods that we make advances in a field. The results of the current study should help CSCL researchers become aware of their own methodological practices and the methodological practices of the field as a whole. We hope that this study will prompt them to take a cautious step toward establishing a better understanding of different practices so that the field can work towards more productive conversations among CSCL researchers and a more meaningful synthesis of CSCL research.

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