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JrnlID 11412_ArtID 9188_Proof# 1 - 30/12/2013

Intern. J. Comput.-Support. Collab. Learn.
DOI 10.1007/s11412-013-9188-x

Fostering collective and individual learning through knowledge building

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Received: 22 May 2013 / Accepted: 19 December 2013
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Abstract The purpose of this study was to design and examine a computer-supported knowledge building environment and to investigate both collective knowledge-building dynamics and individual learning in the context of a tertiary education course in mainland China. The participants were 102 students in four intact Year one tertiary business classes. Two classes experienced a knowledge-building environment (CKB) and the other two were taught using a regular project-based approach (RPBL). Data were obtained from interactions in the forum, writing quality, group-learning portfolios, and surveys. Quantitative analyses indicated that the knowledge-building groups outperformed the comparison groups on academic literacy assessed in terms of conceptual understanding and explanation, and obtained higher scores on beliefs about collaboration. Within-group analyses indicated that the students' engagement in Knowledge Forum was a significant predictor of their academic literacy. Qualitative contrastive analyses of high- and low-performance groups identified different patterns of conceptual, metacognitive and social processes, and showed that student groups engaging in more collective and meta-discourse discourse moves performed better on individual scores in academic literacy. The implications of examining both collaborative dynamics and individual learning and designing computer-supported knowledge building for tertiary students are discussed.

Keywords Collaborative knowledge building · Computer-supported inquiry · Academic literacy · Technology-enhanced learning environment · Higher education

Introduction

Over the past two decades, the focus of cognitive research has switched from individual learning to collective and social processes of learning (Anderson et al. 2000; Bereiter 2002;

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Brown et al. 1989; Stahl 2006). Theoretical advances and the rapid development of Internet technology provide great potential to scaffold CSCL (Koschmann et al. 2002; Stahl 2002, 2006). Substantial progress has been made in terms of scaffolding collaborative inquiry in scripting (Fischer et al. 2013), collaborative argumentation (Scheuer et al. 2010), the analysis of collaborative discourse (Puntambekar et al. 2011; Suthers et al. 2010), and the design of CSCL technology (Jermann et al. 2004). CSCL has also received increased attention regarding its applicability to technology-enhanced collaboration in higher education (Strijbos et al. 2004; Resta and Laferrière 2007). In particular, the notions of group cognition (Stahl 2006) and collective cognitive responsibility (Scardamalia et al. 1994; Scardamalia and Bereiter 2006) for collaborative knowledge building provide important theoretical foundations for the development of computer-supported collaborative learning (CSCL). Q3

Increased research interest is now being given to CSCL in practice and an issue of interest is learning across levels, and how CSCL can be designed to enhance collective and individual learning in complex classroom settings, with emphasis on both processes and outcomes. Earlier research in educational technology and networked learning has focused on pre- and post-test differences (Carle et al. 2009) or analyses of student experience (Goodyear et al. 2005), but with limited analysis of collaborative processes. Major progress has been made in CSCL studies theorizing and identifying collaborative dynamics (e.g., Baker et al. 2007; Hmelo-Silver 2003; Meier et al. 2007; Suthers et al. 2010) but with less attention to CSCL instructional effects. While micro-level process studies have illuminated the potential of CSCL for collaborative knowledge building, they have not addressed whether and how the positive benefits can be diffused to individuals.

There is now increased interest in examining the relationships between collaborative processes with individual learning (e.g., Molenaar et al. 2011; Paus et al. 2012; Rummel and Spada 2005; Weinberger et al. 2005). Although CSCL design has shown positive effects, fewer studies have investigated how collaborative processes influence individual learning. This study followed this line of inquiry with a focus on linking design, process and learning, and specifically examining how CSCL classroom design is related to collaborative processes and individual learning. While there have been many separate studies examining CSCL design, collaborative dynamics, scaffolding processes and tools, more classroom-based research using an integrated approach is needed to advance CSCL in practice and to *address the issue of how to design a CSCL environment to scaffold collective processes with impacts on individual learning.*

The study reported in this paper adopted the knowledge building research framework (Scardamalia and Bereiter 2006) mediated by Knowledge Forum, a computer-supported collaborative learning environment that has attracted much attention from CSCL researchers. In knowledge building, students' ideas are viewed as conceptual artifacts and objects of inquiry that can be improved continually via progressive discourse supported by affordances of Knowledge Forum. Comparing their own models with those of their peers can enhance students' metacognitive understanding by inspiring questions and providing explanations through collective inquiry. Although there has been a substantial amount of research, most of it has been conducted in elementary-level science classes or other K-12 settings. How tertiary students engage in knowledge-building dynamics, the conceptual, meta-cognitive and collective processes mediated by Knowledge Forum, and how such collective processes can impact upon learning, need to be examined. Such investigations seem to be particularly useful in tertiary university contexts in mainland China, considering the challenges posed by social-cultural contexts, especially the tensions between collective learning processes and individual academic outcomes escalated by pressure from society and the job market. This study, conducted in a non-Western socio-cultural setting, in which students are highly competitive, may also suggest new questions and possibilities for CSCL.

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Accordingly, this study examined the design of a knowledge-building environment for tertiary students for collective and individual learning. First, we investigated whether the designed environment promoted academic learning and beliefs about collaboration compared to a regular project-based environment; Second, we examined the predictive role of Knowledge Forum participation in student academic learning (e.g., business concept learning and academic literacy); Third, we identified productive collaboration dynamics supported by the knowledge-building environment through contrastive group analyses and, finally, we investigated the relationships between collective processes and individual learning.

Perspective of collective knowledge building

Knowledge building, as an educational model, emerged in the 1980s, and has developed into an integrated framework of knowledge-building theories, pedagogies, practices and technology-enhanced environments (Bereiter 2002; Scardamalia and Bereiter 2006). Central to knowledge-building theory is the notion that knowledge is a social product, created by members, that adds value to the community (Scardamalia and Bereiter 2003). Bereiter and Scardamalia (1996) and Scardamalia (2004) distinguished knowledge building from knowledge acquisition or participation as students create and improve ideas for community advances. Students' ideas can be examined, tested, refined and improved upon through collaborative inquiry discourse (Bereiter 2002); this focus on the collective advancement of communal knowledge distinguishes knowledge building from other models of learning. While knowledge building emphasizes *collective dynamics* and advances, students also learn and *individual learning* such as literacy can be a by-product (Scardamalia and Bereiter 2003; Scardamalia et al. 1994).

Knowledge building places emphasis on collective growth; through computer-supported collaborative inquiry, it transforms classes into communities of inquiry to identify gaps in existing communal knowledge, and to design and initiate collaborative inquiries into unknown areas. Through progressive inquiry, participants are expected to create, work on, and improve ideas (epistemic objects), utilize collective problem-solving and inquiry skills (meta-cognitive skills) and advance their communal knowledge base. This goes beyond instructional models that focus on knowledge integration and participation, and aims to transform existing knowledge and create new-ideas through progressive inquiry.

Informed by knowledge-building theory, Knowledge Forum, a technology-enhanced group learning environment, was designed to provide rich opportunities for objectifying the progress of knowledge building and advancing collective knowledge (Scardamalia 2004). It aims to facilitate the transformation of the traditional classroom into a knowledge-building community. Students contribute or build on computer notes, consisting of questions, explanations, evidence, experiments and/or reference materials, to help advance communal knowledge through synthesizing different views to improve collective ideas. Basic Knowledge Forum features include scaffolds that can act as epistemic markers to facilitate metacognition; build-on and rise-above functions, which enhance idea improvement; and graphic views, which present different visual perspectives on the public discourse to affect communal knowledge advancement.

The knowledge-building model has been implemented at various levels of educational institutions and workplaces. Over the past two decades, empirical research has indicated its benefits for scientific inquiry (Hakkarainen 2003); conceptual understanding (Lee et al. 2006); vocabulary growth (Sun et al. 2010); and graphical literacy (Gan et al. 2010). Research has also examined the design of knowledge building (Caswell and Bielaczyc 2010; Hewitt and Scardamalia 1998), the nature of knowledge-building and inquiry (Hakkarainen 2003; Lee

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et al. 2006), technological development (Scardamalia and Bereiter 2003), and capturing the communal growth of ideas (Zhang et al. 2009). Despite much progress in knowledge-building research, concerns exist as to whether the CSCL knowledge-building model, which focuses on community advances and inquiry processes, will affect both collective and individual learning. While some early knowledge building research did examine evaluation components (e.g., Scardamalia et al. 1994), most recent efforts have been devoted to elucidating the rich dynamics of knowledge-building processes (Zhang et al. 2007, 2009). Stronger empirical evidence, including the use of comparison groups, would be useful for investigating the effects of knowledge-building designs on both learning outcomes and processes. As knowledge building requires an emergent approach, how to design it for higher education settings with various institutional constraints also merits attention.

This study set out to design a knowledge-building environment and examined both collective and individual learning: It utilized multiple data sources and multiple analytical methods, including both quantitative pre- and post-test measures, to assess the effect on academic performance and beliefs about collaboration, as well as online qualitative discourse analyses for both individual and communal knowledge advances. Recent studies have posited that student belief and epistemology are critical factors influencing other factors in the ecology of learning innovation (Bielaczyc 2006; Tsai 2009). It would be useful to examine whether students working in knowledge-building environments moved towards more sophisticated beliefs. From a theoretical standpoint, there is interest in examining whether CSCL models, focusing on collective processes such as knowledge building, will influence individual student learning. From a practical perspective, there will be educational implications for the feasible implementation of CSCL practice in tertiary classrooms, an area in which few CSCL studies have been reported. Such a preliminary study may provide useful information for optimizing the design to be more appropriate to different social-cultural and educational settings.

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Analysis of collaborative and knowledge building processes

A second theme of the study was to investigate the kinds of collaborative processes and discourse patterns that characterize knowledge-building discourse and to examine how these might contribute to learning outcomes. A wealth of studies on CSCL have focused on analyzing discourse processes and dynamics to gain a deep understanding of how learning and collaboration take place mediated by computer technology (e.g., Baker et al. 2007; Fischer et al. 2013; Hmelo-Silver 2003; Meier et al. 2007; Pifarre and Cobos 2010). Research efforts in coding such patterns are important, as they might illuminate the kinds of collaborative processes in which students engage that may influence their learning and understanding.

CSCL research on coding has identified the importance of conceptual, cognitive and social processes. For example, Hmelo-Silver's fine-grained content analysis (2003), which coded notes turn-by-turn, yielded a multi-faceted coding scheme, characterizing conceptual, cognitive and social features of collaborative knowledge construction. Her research adopted multiple-dimensional and multiple-coding approaches to unravel multi-faceted and interwoven learning and collaborative knowledge construction processes. Fischer et al. (2013) developed schemes that identify, from content/concept and functional perspectives, four interwoven collaborative knowledge construction processes, including externalization, elicitation, integration-oriented and social conflict-oriented consensus building. Muukkonen and Lakkala (2009) further characterized collective inquiry into advancing shared objects using a coding framework that identified progressive inquiry processes, and included questioning, explicative and theoretical knowledge, meta-knowledge and organization, and communal knowledge advancement. Meier et al. (2007) used a rating scheme in their coding approach to identify different processes and patterns that can be coded with different degrees of intensity.

Researchers in the knowledge-building tradition have also employed multiple methods to capture knowledge-building dynamics and processes (see review, Chan 2013). Analyses of Knowledge Forum participation, contribution and interaction have utilized server log information to characterize the nature of interactive activities. A data analytic software package, Analytic Toolkit (ATK) (Burtis 1998), was developed to provide an overview of the main quantitative indices for contribution, interaction and collaboration, including the number of notes written or read, scaffold uses and note revisions, among others. Studies have also shown that the Knowledge Forum engagement measured by ATK is correlated with students' conceptual understanding (Lee et al. 2006; van Aalst and Chan 2007).

Other analyses of collective knowledge building have examined the epistemic nature of progressive inquiry in terms of the quality of questions asked and explanations provided (Hakkarainen 2003, 2004). These analyses have demonstrated how collaborative inquiry discourse has deepened over time, as students generate higher-level explanation-seeking questions and provide more elaborate explanations. Lee et al. (2006) further characterized *depth of inquiry* as varying at the question level, from simple and general questions, to those identifying gaps in understanding, to explanation-driven questions, and *depth of explanation* as varying from simplistic fact regurgitation to more sophisticated explanations synthesizing and taking up different ideas from the community.

Given the increased emphasis on social and collective aspects, additional attention must now be paid to analyzing group cognition and collective aspects of knowledge-building dynamics (Stahl 2006). While rich analyses of knowledge-building dynamics have been conducted using inquiry threads (Zhang et al. 2007), it would also be helpful to examine whether collective dimensions of collaboration can be identified in group discourse; for example, recent studies have used portfolios to characterize the collective growth of communal knowledge (Lee et al. 2006). Van Aalst (2009) examined and distinguished between three collective discourse modes: knowledge sharing, knowledge construction and knowledge creation. His study's identified discourse moves included information, questions, ideas, emergence, meta-discourse and social dynamics; the findings provided useful evidence of the role of social dynamics (community) and social processes in advancing collective knowledge.

Despite much progress in analyzing knowledge building, fewer studies have linked knowledge-building designs with collective processes and individual gains. As knowledge-building designs that emphasize community advances bring about more collective discourse moves, there is a need to investigate how those moves manifest themselves. Furthermore, there is a need to examine discourse processes associated with individual gains to identify which collective discourse moves yield individual learning gains. Such theoretical questions are worth investigating in different settings, particularly in Asian classrooms, where academic performance plays an important role in a high-stakes testing culture. This study investigated actual collaboration processes for knowledge-building inquiry to unravel how student participation in a CSCL/ Knowledge Forum environment may manifest metacognitive, epistemic and social activities and processes.

Domain and context of inquiry

Academic literacy in higher education has been the focus of world-wide research, particularly in universities using English as a medium of instruction (Braine 2002). Research into academic literacy has extended the concept to include far more than simply the language, reading and Q9

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writing skills required for academic studies in higher education; recent studies based on socio-cultural approaches have defined academic literacy as higher-order learning/thinking in pursuit of deep collaborative contextual meaning (Lea and Street 2006) in the academic socialization process (Granville and Dison 2005). In this context, CSCL and knowledge building have the potential to promote academic literacy, in addition to enhancing motivation and engagement (Tan et al. 2010). Specifically, students' academic literacy can be improved through a dynamic Q10 and continuous process of advancing communal knowledge and understanding (Scardamalia et al. 1994). Recent research has shown the reciprocal relationship between knowledge building and reading skills in elementary students (Zhang and Sun 2011).

While a lot of knowledge-building research emphasizing collective advances (Scardamalia and Bereiter 2006) has been conducted in K-12 settings and science domains, more research is needed on the design, analyses and effects of knowledge building in different educational and cross-cultural contexts, and there is a perceived need to extend the inquiry line to include under-investigated domains in higher education, such as business studies and academic literacy (Yeh et al. 2011). Although emerging goals in business education emphasize knowledge creation, collaboration and life-long learning (Dosi et al. 2000; Eastman and Swift 2002; Hanson and Sinclair 2008), little is known about the effect and process of computer-supported project inquiry in business studies. Despite research evidence suggesting a scaffolding role of the technology-enhanced business project approach on metacognitive and team skills (Ngai 2007), few studies have, to date, examined how computer-mediated conceptual learning and collective knowledge advances are interwoven with the metacognitive and social processes of project learning. Moreover, although academic literacy is emphasized as a core competency in higher education, especially in countries where English is a foreign language, there is insufficient research examining academic literacy development embedded in collaborative inquiry processes.

With increased interest given to CSCL practice in the classroom, more research attention needs to be paid to CSCL impacts on both the collaborative process and academic learning, and the Asian classroom provides an interesting research context. In light of dramatic changes in educational goals and societal demands for collaboration and knowledge creation, Chinese higher education reforms have been confronted with unparalleled challenges when transplanting such novel educational models as CSCL and knowledge building, particularly due to deeply-entrenched impacts of individual testing conventions and escalating competition from the increasingly fierce job market. Transforming CSCL pedagogies in Chinese tertiary classrooms demands full consideration over both the underlying theoretical principles and the perceived prevailing contextual constraints, such as the tensions between collaboration and competition. Thus, addressing both CSCL processes and learning outcomes tends to be an appropriate approach to inquiring into how CSCL develops in tertiary settings in mainland China. In fact, both theoretical considerations and pragmatic demands call for deep inquiry into the links between collective processing and individual learning. In light of this, this study set out to investigate how conceptual understanding and academic literacy are deepened and promoted by computer-supported knowledge building processes in collaborative business project inquiry.

In summary, the study involved designing, implementing and evaluating a knowledge-building inquiry environment for Chinese tertiary business students. Specifically, three research questions were addressed:

1. What are the instructional effects of the designed computer-supported knowledge-building (CKB) environment on students' academic literacy and their beliefs about collaboration?

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2. What is the role of student participation on Knowledge Forum and specifically how is it related to students' academic learning after course instruction?
3. What characterizes productive knowledge-building discourse patterns; what are the differences between high- and low-performing groups? How is collective inquiry processing related to individual learning performance?

Methods

Participants

This study was part of a larger project to design, evaluate and investigate tertiary students' learning and collaboration, mediated by the use of technology. The participants were 102 students (Female=57, Male=45) in four intact Year 1 English for International Business (EIB) classes, part of a joint Sino-British program at a university in Shanghai. Informed by a pre-teaching investigation, the four classes were similar in achievement levels, instructional experiences and gender composition. The students generally performed at below-average levels, compared with same-year students in other programs. A quasi-experimental design was employed: two tutors, including the first author, each taught two classes—an instructional class using computer-supported knowledge-building inquiry (CKB), and a regular class using regular project-based learning (RPBL). Another tutor was included to examine whether the designed CSKBI approach could be implemented by other EIB tutors, given appropriate training and scaffolding.

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Research context

The research was conducted in a core English for International Business module intended to develop deep conceptual and contextual understanding of Total Quality Management (TQM) and basic research and academic literacy skills. The 12-week module originally featured a self-designed group project investigating TQM implementation in real businesses in Shanghai. The project-based learning design, developed by the UK partnership university, was, in itself, innovative, as lecture-based and teacher-led instructional approaches still prevail in Chinese tertiary classrooms. However, our pilot study findings (Zhao and Zheng 2013) revealed that students worked together on project learning mainly to complete the shared task, rather than to advance communal knowledge. The sum of individual work was reported as a major outcome of group learning. Moreover, as the project was conducted in an English-as-a-Foreign-Language setting after class, the use of English appears to be realistically difficult. The students reported that little improvement had been observed in English literacy through PBL learning. Drawing on the previous findings, a knowledge-building environment based on knowledge-building principles emphasizing collective cognitive responsibility was therefore designed to facilitate changes in learning and collaboration and to promote academic and professional English literacy.

The two project-based learning comparison groups mainly followed this original instructional design. The in-class activities included lectures on business knowledge and research methods and student-centered English communicative activities; after-class project work consisted of sequential stage-based tasks following a project procedure prescribed by tutors (see Table 2).

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Designing the knowledge-building environment

Informed by knowledge-building pedagogy and higher education reforms emphasizing academic literacy and collaborative inquiry, a computer-supported knowledge-building inquiry (CKB) environment was designed. The CKB environment enriched the project-based learning using knowledge-building to foster socio-cognitive dynamics through the principle-informed use of Knowledge Forum.

Knowledge-building principles and technological dynamics

The CKB environment employs the knowledge-building approach to design, implement and assess knowledge advancement in dynamic collective inquiry. Scardamalia (2004) theorized twelve knowledge-building principles to characterize such dynamics, including real ideas and authentic problems, improvable ideas, epistemic agency, rise-above, knowledge-building discourse, constructive uses of authoritative information, democratizing knowledge; community knowledge and pervasive knowledge building. Based on the preliminary findings in other Chinese classrooms (Chan 2011; Lee et al. 2006), we adapted three major ones as design principles in this study: epistemic agency, improvable ideas and community knowledge; these three principles have been examined in most knowledge-building classroom studies (e.g., Zhang et al. 2009). The environment's overarching theme was collective cognitive responsibility, which involves creating social-cognitive dynamics to facilitate students' efforts to advance knowledge collectively through the intentional use of English.

Epistemic agency refers to taking on epistemic and meta-cognitive roles to identify inconsistencies in the discourse. The focus is on meta-cognition, reflection and collective regulation for idea-improvement or deep question-explanation discourse, rather than on the simple completion of project tasks; and relying on collective problem solving rather than a division of labor. Scardamalia (2004) noted that students taking on epistemic agency compare different models and work with conflict to spark individual and communal progress.

Improvable ideas involve students in viewing ideas as shared knowledge objects that can be explored, examined and improved upon; synthesizing different perspectives and evidence from multiple sources for collective idea improvement; progressively improving ideas in connection with the broader community; and deepening both conceptual processing and collective problem solving.

Community Knowledge involves students working together and using effective communicative strategies to allow improved ideas and theories to diffuse through the communal knowledge space; a collective commitment to advancing communal knowledge through technological and language media; working on social dynamics; emphasizing collective rather than individual advances; and using meta-discourse to reflect on knowledge advances.

Knowledge Forum was used to facilitate knowledge-building inquiry by engaging students' in the co-construction of a collaborative workspace. The researchers designed different views, including a 'Welcome View' to organize and navigate the online group inquiry. 'Views' are communal workspaces, wherein participants contribute 'notes' (including questions, explanation, and sometimes hyper links to other online resources). Lines linking the notes show group connections, such as when other students have made responses, built on to the concept, or referenced to other notes in the database. Writing a new note or responding to others' notes opens a new window with a self-designated note title; note writing is guided by KF's embedded scaffolds.

One of the key features of Knowledge Forum is scaffolds or epistemic markers (e.g., "I need to understand", "My theory", "New information", "A better theory", "Putting our

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knowledge together"), which can be used flexibly with no fixed sequence to support deeper thinking. These scaffolds have been shown to effectively execute social metacognition in the process of collaborative inquiry (Hakkarainen 2003; Lee et al. 2006). They involve collaborative components, as they signal to others what to read and what to search in the communal knowledge base. Summary note writing, considering what the group has discussed and advanced, helps to enhance reflection, synthesis and rise-above in meta-discourse (Lee et al. 2006; van Aalst 2009). Based on the theoretical grounding (Scardamalia and Bereiter 2006), and empirical research (Zhang et al. 2007; 2009), we expect that knowledge-building design, supported by Knowledge Forum, can facilitate students to articulate and reframe their ideas as they engage in conceptual processing and raise high-level questions and explanations; they will reflect metacognitively on personal and communal understanding; primarily they will work on pursuing both individual and communal understanding. This study investigated how Knowledge Building designs including scaffolds may be related to academic learning, and how knowledge-building principles focusing on collective responsibility will bring about collective processes and individual learning through analyzing students' online discourse (see Results section).

Implementing knowledge building in Chinese tertiary classrooms

Both knowledge-building and comparison classes had a curriculum on Total Quality Management (TQM) with inquiry-based learning and including student groups working on an investigative project examining TQM in the real-world business context. Unlike the regular project-based learning environment, the computer-supported knowledge-building inquiry (CKB) environment was designed based on knowledge-building principles, supported by Knowledge Forum, and the curriculum and teaching activities were designed to facilitate the collective knowledge-building process. Specifically, knowledge building activities were relatively unstructured, student-initiated and problem-driven. Design efforts focused on facilitating collaborative inquiry, enhancing collaborative processing of related concepts -scaffolding group inquiry, modeling exemplar collaborative inquiry discourse episodes, and group portfolio assessment—to foster reflection and collaboration. The detailed design of the CKB learning environment, embedding knowledge-building principles and following successful knowledge building models in Asian classrooms (e.g., Chan 2011), is outlined below.

Cultivating collaborative inquiry classroom culture As shown in the literature, productive collaborative inquiry is premised on a successfully cultivated collaborative learning culture (Zhang et al. 2009). This appears to be particularly important for Chinese tertiary students, who have been accustomed to a teacher-centered, didactic class culture. Group activities encouraging student participation were designed and used in class to facilitate *epistemic agency* and active engagement in collaborative learning. In addition, students were asked to form their own inquiry groups with a team agreement on how to advance their knowledge and understanding collectively (see van Aalst 2009). These activities cultivated a favorable climate for collective cognitive growth and fostered deep collaborative inquiry.

Scaffolding progressive inquiry and improvable discourse Students started putting forth ideas and engaged in collective inquiry in Knowledge Forum using scaffolds; they posed problems and ideas that emerged from their difficulties in tackling the course materials (i.e., TQM) and these ideas are objects to be improved. The students' understanding of these ideas was tested by their engagement in project inquiry. In addition to inquiry into key concepts, Knowledge Forum discussion views were set up for each inquiry group, in which the group members

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could, after class, post authentic problems, respond to notes and provide useful links to information from different sources. Discussion and inquiry in KF was nurtured as an extension of classroom inquiry discourse in relation to key concept learning or project design. Students were encouraged to develop collective agency by managing their group discussion views and to initiate deeper inquiries by applying business concepts to actual economic or management problems. At this stage, students worked collectively on improvable ideas, intentionally seeking out resources, using embedded scaffolds for concept learning and project inquiry, and participating in online discussions modeling exemplar collaborative inquiry discursive practices.

The interaction between classroom events, project inquiry, and Knowledge Forum discourse was another distinctive design feature. Students' online inquiries can inform the ways in which tutors design in-class teaching activities. In their KF discussions, the students showed a tendency to present information with little elaboration and to articulate their isolated understanding of related TQM concepts; for example, at the beginning of one two-week TQM project inquiry, the students were confused by definitions of quality and TQM taken from different sources. To address this problem of superficial conceptual understanding, opportunistic teaching took place; a concept-mapping activity was included for the following in-class teaching session, in which project groups were asked to draw and elaborate on a diagram that showed their understanding of quality. This class activity, in turn, facilitated more online discussions and deepened the inquiry discourse.

Emerging and deepening inquiry and agency After the initial stage of scaffolded inquiry, students were encouraged to discuss any problems pertaining to concept learning (TQM, for example), project design and implementation, or on-site investigative findings. Ideas were generated and developed around topics that interested the project groups. Teacher scaffolding included encouraging the students to identify themes surrounding a note thread that should be recognized, synthesized and summarized for community knowledge building; in this way, the students could be made responsible for advancements in their collective understanding. At this stage, the teacher's input faded away, unless a group's online inquiry was stuck or group dynamics became worrisome.

Collective reflection and assessment Assessment is another key design element of the CSCL environment. As in many other studies from social cognitive and social constructivist perspectives, or from that of the constructive alignment of learning, assessment and collaboration, assessment serves a mediating role in a computer-supported knowledge building environment (van Aalst and Chan 2007). Students were asked to write notes to reflect and to assess their own project inquiry for metacognitive reflection and collective agency. Online and offline work merged to situate knowledge building in classroom practice. Students worked in groups presenting their understanding and they wrote group portfolios to identify evidence of collaborative learning in project inquiry and online KF discussions, and to identify cognitive and linguistic gains from online collaborative learning experiences. The students were required to provide evidence of collaborative project inquiry, such as the project team agreement, progressive self- and peer-evaluations, selections of KF discussion note clusters indicating collaborative efforts, or records of critical incidents in the collaborative process.

To summarize, both CKB and RPBL classes follow the UK partnership curriculum with similar content and assessment standards for quality assurance; and all students had to work in groups to conduct an investigative project situated in authentic business context. While RPBL classrooms emphasize communication, interaction and project inquiry, the CKB classrooms

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emphasize collective cognitive responsibility for collaborative knowledge building. Table 1 (below) illustrates the design differences between CKB and RPBL environment.

Data sources and measures

To address the research goals, multiple sources of data were collected, including essay writing for academic literacy, questionnaire surveys exploring student beliefs about collaboration, group project learning portfolios, online discussion notes for collaborative processes, and English academic language scores.

1) Essay writing for academic literacy

   To assess academic literacy, both knowledge-building and regular groups were required to write an essay in Week Six to be completed as an end-of-term course assessment [Discuss the statement that Chinese businesses should adopt Total Quality Management (TQM) in order to succeed internationally]. Using writing tasks to assess academic literacy has been accepted widely in the domains of English for Academic Purposes (Short et al. 2011; Wen and Zhou 2006). Writing tasks have also been employed to assess students' conceptual understanding in knowledge-building research (e.g., Lee et al. 2006). Essays were analyzed using a four-dimensional rubric adapted from the prescribed school assessment criteria and informed by the established rating rubrics (Lundstorm and Baker 2009). Specifically, academic literacy consists of four subscales including: (a) conceptual understanding (students' grasp of key management concepts); (b) argument and explanation; (c) organization; and (d) use of language. The sum of the four-dimensional scores was used as a measure of academic literacy. All the essays were blind rated independently by the first author and another teacher. The inter-rater reliability coefficients, based on Pearson Correlation, were .80 for conceptual understanding, .82 for explanation, .81 for organization, and .84 for use of language.

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Table 1 Comparison of design of CKB and RPL classes

	CKB groups	RPL groups
Classroom talk	Student ideas visible via discussion	Language communication skills-focused and information sharing
Student activities	Reading and group inquiry to generate hypotheses/ideas;	Sequential stage-based tasks Interacting with business community for information;
	Interacting with business community for hypothesis testing and deep understanding;	Active involvement but for task-completion
	Epistemic agency activated; problem-driven	
Group work	Community advances	Cooperation
		Sum of division of labor
Use of resources	Constructive use of resources—elaborating, reasoning, questioning, rising-above from discussion.	Understanding and make full use of resource to complete tasks
Technology	KF online platform to advance collaborative inquiry discourse	No designed technology or students' ad-hoc use of online platform
Assessment	Use of group portfolio to scaffold collective and metacognitive reflection and evaluation	Use of group portfolio as collection of individual and co-operative work

2) Survey on beliefs about collaboration

The study also investigated the effects of the knowledge-building environment on student beliefs about collaboration by administering a questionnaire survey in a pre- and post-test manner, using an adapted Collaborative Learning Scale (Chan and Chan 2011). In the survey, the students rated their agreement with such statements as, "We help each other to make knowledge advances together". Cronbach's alpha coefficients were .87 and .80 in the pre-and post-tests.

3) Group portfolio on academic learning

Knowledge building project groups were required to prepare group portfolios, including evidence- and analysis-based group reflections on collective inquiry with reflections on their academic writing process (draft writing, peer review comments, and reflection). The portfolios, that examine group academic literacy, were rated on a 6-point scale, based on a coding scheme that measured conceptual understanding, group dynamics, and reflection. The portfolios assessed students' academic literacy and collaborative inquiry and they also served as a basis for identifying contrastive groups for analyses of discourse patterns.

4) Analytical toolkit and database participation. The Analytic Toolkit (ATK) for Knowledge Forum (Burtis 1998) was used to provide an overview of the main quantitative indices for KF database participation. ATK indices have been employed in various research in knowledge building to show student participation (Lai and Law 2006; Zhang 2009). In this case, server log information was analyzed, including the number of notes written, notes read, scaffold uses and note revisions.

5) Online Discourse Notes. Students' Knowledge Forum notes were analyzed to identify collaborative knowledge-building processes. Different kinds of conceptual, metacognitive, epistemic and social processes, differing from individual to collective focus, were identified (see later section on coding).

6) Prior Academic achievement

The students' Business English language academic proficiency scores from the previous year were collected as an indicator of their academic and language ability. The Business English test, equivalent to the Business English Certificate (BEC) test at the intermediate level, consisted of three parts: listening (35 %); reading (35 %); and business English writing (30 %). These test scores that measured students' academic-language skills were used as covariates when testing the effects of the knowledge-building environment. We use these academic English scores as covariates because they provide important information on students' achievement; they are similar to GPA but more relevant because they are domain-specific scores. Students' entrance to the programs or placement into different programs is determined by these English academic-language proficiency scores. As students wrote on Knowledge Forum in English, it is also important to ascertain that the variation is not merely due to differences in English skills.

To summarize, the choice of quasi-experimental design together with in-depth discourse analyses using multiple methods was to address the research goals that involve examining both CSCL processes and CSCL effects and their relationships. We used an increasingly deepening approach examining if there are differences between the designed versus regular classrooms on learning effects. We next examined the role of knowledge building design and dynamics, and specifically if Knowledge Forum participation was a predictor for learning; we then conducted qualitative analyses to identify discourse patterns and then examined how collective discourse processes were related to individual learning. Importantly, the study was to understand how students engaged in collaborative knowledge building and how the discourse patterns contributed to individual academic

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learning. This study also included offline data on student interviews and classroom data as they were important for the formation of knowledge-building culture in classroom. However, due to the wealth of data, we have not included them in this paper. We now present the research framework illustrating the alignment of research goals, research questions, data sources, and measures, and analysis in Table 2.

Results

Effects of knowledge building environment on student learning

The first research question investigated whether students in the knowledge-building environment had higher scores on their academic literacy and beliefs about collaboration after instruction compared to their counterparts.

Instructional effects on academic literacy Academic literacy was assessed using an essay writing task at the end of the course instruction. The mean scores and standard deviations of four dimensions of academic literacy are shown in Table 3. To examine the effect of the knowledge-building environment on academic literacy, a two-way MANCOVA (environment X teacher) was conducted, controlling for differences in pre-test academic-language scores. The multivariate results indicated significant main effects on environment - (F (4, 94)=3.36, $p<.05$, $\eta^2=.12$) indicating that KB group performed better than the comparison group. There were no teacher effects. The follow-up univariate analyses on different dimensions showed significant differences in conceptual understanding (F (1, 97)=6.77, $p<.01$, $\eta^2=.07$) and argument-explanation (F (1, 97)=8.03, $p<.01$, $\eta^2=.08$) favoring the knowledge-building

Table 2 Research framework: goals, questions and analyses

Research goals	Specific research questions	Measures and analyses
1) To examine the instructional effects of the designed CKB environment on individual learning beliefs & outcomes	Did the CKB students perform better than comparison students on academic literacy and beliefs about collaboration after instruction?	Quantitative Analyses: Compare group differences after course instruction:
		-Essay writing on academic literacy; survey questionnaires on beliefs about collaboration controlling for differences in prior achievement levels
2. To examine the role of Knowledge Forum participation on student learning	How is student participation in Knowledge Forum related to academic literacy?	Quantitative analysis: correlation and regression analysis: Knowledge Forum participation measured by server log data
3. To identify the collaboration dynamics supported by the knowledge-building environment and to investigate the relationships between collective processes and individual learning	What characterizes students' knowledge-building discourse patterns and how is collective processing manifested? What were the differences between high and low-performing groups? How were collective processes related to individual learning?	Qualitative analyses of Online discourse & contrastive group analysis: Knowledge Forum notes from eight selected groups; Comparison of discourse patterns between high-low groups; correlation of collective discourse patterns with academic literacy scores

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Table 3 Means (standard deviations) for academic literacy and beliefs about collaboration

	Academic literacy				Beliefs about collaboration	
	Conceptual understanding	Argument—explanation	Organization	Language	Pre-test	Post-test
Regular (n=49)	47.98 (10.49)	47.59 (10.33)	49.51 (9.89)	48.11 (10.56)	3.49 (.80)	3.47 (.56)
Knowledge building (n=53)	52.28 (9.10)	52.38 (9.40)	50.48 (10.24)	51.90 (9.40)	3.41 (.69)	3.73 (.62)

groups. This result indicates that knowledge-building groups outperformed the comparison groups in conceptual aspects of academic literacy. No significant differences were obtained in organization or use of language, the mechanic aspects of academic literacy.

Instructional effects on beliefs about collaboration Students' beliefs about collaboration were assessed using a questionnaire at the beginning and end of course instruction. Table 1 shows means and SD on beliefs about collaboration in the knowledge-building groups and comparison groups at pre-test and posttests. To examine the effects of the knowledge-building environment on students' beliefs about collaboration over time, two-way repeated measures analyses (time x teacher) were conducted. The results indicated significant interaction effects of time and environment on beliefs about collaboration (F (1, 100)=9.52, p<.01, η^2=.09) favoring the knowledge-building groups, suggesting that they developed more sophisticated beliefs about collaboration. There were no interaction effects on teacher factor. These findings, taken together, suggest that students in the knowledge-building environments obtained higher scores on academic literacy and changed more in their reported beliefs about collaboration.

Prediction of knowledge forum participation on academic literacy

The second research question investigated the relationship between Knowledge Forum participation and academic literacy, specifically whether students' online KF participation predicted their level of academic literacy. Students' Knowledge Forum participation was examined using server log information via the Analytic Toolkit (ATK), developed by the University of Toronto team (Burtis 1998). We selected four indices commonly employed in classroom research on knowledge building (Lee et al. 2006). The means and standard deviations (in parenthesis) of the four ATK indices (notes created, percentage of notes read, scaffolds used and notes revised) were 8.94 (6.2), 25.54 (19.60), 4.95 (6.01) and 2.01 (3.54), respectively.

Correlation analyses were conducted to examine the relationship between Knowledge Forum participation (ATK) indices and academic learning outcomes. Partial correlation analyses, controlling for pre-test language proficiency, were performed (see Table 4) to identify which Knowledge Forum engagement activities (e.g. scaffold use and notes created, read or revised) were related to academic literacy. Of the four KF activities, notes created (r=.30, p<.05) and scaffold use (r=.44, p<.01) were found to be correlated significantly with academic literacy.

Regression analyses were then conducted to examine the predictive effect of Knowledge Forum participation on academic literacy. Considering the relatively small sample size (N=52) and to make the analyses more coherent, the four ATK indices (scaffold use and notes created,

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Table 4 Partial correlations between KF engagement activities and academic literacy controlling for pre-test language proficiency (*N*=52)

		1	2	3	4	5
1	Note created	-				
2	Note read	.56***	-			
3	Note-revision	.33*	.42**	-		
4	Scaffold use	.75***	.49***	.42**	-	
5	Academic literacy	.30*	.25	.04	.44**	-

* *p*<.05, ** *p*<.01, *** *p*<.001

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read or revised) were combined into a KF participation index using factor analysis, explaining 55.72 % of the variance (Eigenvalue 2.23); such procedures have been employed in other knowledge-building studies (van Aalst and Chan 2007). Hierarchical multiple regressions were used to examine the predictive role of participation in Knowledge Forum on academic literacy. As students' academic-language ability and beliefs about collaboration may influence their academic literacy, they were entered in succession, followed by KF participation. The results of the regression analyses are shown in Tables 3 and 5. Q12

The results showed that pre-test English proficiency contributed significantly to academic literacy (R^2=.36, F (1, 50)=28.11, p<.01). When belief about collaboration was entered, a small increment of 2 % of the total variance was detected, R^2=.38, F (2, 48)=14.74, p>.05; (not significant). When Knowledge forum participation was entered, a significant increase of 6 % of the total variance was observed, R^2=.43, F (3, 48)=12.17, p<.05. These findings indicate that, as expected, the students' pre-test achievement levels were an important predictor of academic literacy. In addition, our findings also showed that students' participation in Knowledge Forum makes further contributions to their academic literacy over and beyond the effect of prior achievement and beliefs about collaboration.

Characterizing and analyzing knowledge building discourse

The quantitative results showed pre-posttest differences and indicated that Knowledge Forum participation predicted academic literacy. Further analyses were conducted to investigate what collaborative knowledge-building processes might explain the observed positive effects. Research question three investigated knowledge-building discourse dynamics and examined their relationships with the students' academic performance. Qualitative online discourse analyses were conducted to unravel the complex conceptual, cognitive and collaborative processes of project inquiry and to identify productive discourse moves further. The study adopted methods commonly used in learning sciences (Chi 2011) and employed in other Q13

Table 5 Regression of language proficiency, belief about collaboration and knowledge forum engagement on academic literacy

	R	R^2	R^2 Change
Step 1: Business language proficiency	.60	.36	.36**
Step 2: Beliefs about collaboration	.61	.38	.02
Step 3: Knowledge forum engagement	.66	.43	.06*

* *p*<.05, ** *p*<.01

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CSCL studies—contrastive group analysis comparing high and low-performing groups, for example, helped to illuminate differences in knowledge-building processes and dynamics (Hmelo-Silver 2003; van Aalst 2009). Based on the results of the written group portfolios (assessing conceptual understanding, literacy, project-based inquiry and group reflection using a 6-point scale), eight groups of students, each consisting of around 5 students, were identified with four high-performing and four low-performing groups for analyses of online discourse patterns. The selection of groups also took into consideration similar note contribution. We selected groups that had made comparable efforts in engaging in Knowledge Forum in term of the number of note contribution, because our interest was to investigate discourse patterns not just contrasting student groups who worked very hard versus those who did not engage in knowledge-building work. Such selection criteria followed what has been suggested in contrastive analyses in understanding discourse patterns (Hmelo-Silver 2003).

Qualitative analysis: Identifying different discourse moves

The eight selected groups' online interactions were analyzed through a combined bottom-up and top-down approach that used students' computer notes as units of analysis; the processes were coded on a group basis, as collaboration is a group not individual function. The development of the coding scheme and analyses for discourse moves, using both theory and data, helped generate a preliminary set of categories that were refined iteratively until a set of empirically derived categories was identified. The coding scheme drew upon theoretical frameworks for social, cognitive and meta-cognitive processes of knowledge construction (Hmelo-Silver 2003), epistemological questioning and explanation (Hakkarainen 2003), and social dynamics in knowledge building (van Aalst 2009). Five major themes emerged from the analyses: (1) conceptual processing, (2) problem-solving, (3) metacognitive reflection, (4) epistemic inquiry and (5) social dynamics.

This study adopted a multiple-coding approach to capture complex, multi-faceted collaborative inquiry processes in which each computer entry may exhibit more than one discourse characteristic. For example, a note may be coded under both problem-solving and meta-cognitive reflection to capture the multi-faceted processes of collaborative learning (see Hmelo-Silver 2003 for a more detailed explanation of multiple coding). Furthermore, notes were not considered in isolation; when coding a note, its relationship with other notes responding to the same question in a thematic thread was also considered.

The five conceptual themes were underpinned by socio-cognitive and collective notions adopted from knowledge-building principles, involving epistemic agency, improvable ideas and community knowledge. Specifically, within each category, the study also identified differences varying from surface-task, individual-oriented processes to more elaborate notions and deeper collective, meta-discourse moves. Whereas many knowledge construction coding schemes include social, cognitive, meta-cognitive or epistemological categories, the key aim of this coding scheme, in line with the theoretical perspective of knowledge-building design, was to identify differences in student engagement in collaboration, from individual towards more collective stances. Table 4 presents the main categories and subcategories of the discourse moves identified following iterative modifications, with definitions and examples.

Conceptual processing Computer notes reflecting conceptual processing involved the students' efforts to understand the key concepts of Total Quality Management (theme of the course). The responses in this category were classified into three levels: *superficial paraphrasing*, without active processing of new information; *elaboration*, which connects new information with and explains it in terms of students' current understanding; and *collective processing*,

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which involves comparing different views and the synthesis of different views to improve ideas and to advance communal understanding.

In contrast, with the paraphrasing of TQM definitions taken directly from textbooks [e.g., "TQM is an organization management approach…"], collective processing was coded for statements when students discussed the state of knowledge and discussion (i.e., meta-discourse) and synthesized the views of group members. Primarily, what was presented was not the student's individual understanding but his/her efforts to capture the collective work of the group, for example:

> "It seems that each holds a different opinion of TQM. A said TQM is something that exists in one's own mind. It is a(n) idea and B agreed. C disagreed and insisted that it is a tool…After [considerable] reading and online discussion… *we came to [see]* that TQM is something that feels like a spirit…it is something mental because…. (*Note #112*)

Problem solving Computer notes were coded for the students' engagement in problem solving for project inquiry, and categorized into three levels: surface task-based, information sharing and collective problem solving. *Surface task-based* refers to statements reflecting the allocation of project tasks and is similar to division of labor. *Information sharing* was coded for statements when members provided information to each other but without focusing on top-level group goals. *Collective problem solving* refers to statements reflecting student agency formulating and solving of problems in a real business context, integrating conceptual understanding with inquiry, rather than treating project as the completion of mini-tasks. In the illustrative example, although the project group was confused by different definitions of TQM, the students engaged in collective problem solving and developed criteria to guide their fieldwork

> "I [was] totally confused with all the concepts and definitions of TQM. Then we started to thing [think] to visit a company first… but which company should we pay a visit to?… *We agreed that this company* should at least have a complete management system.. and it would be better it produces real goods not service"(*Note #113*)

Epistemic inquiry: Question and explanation Hakkarainen (2003) discussed epistemic inquiry in terms of questions and explanations; analysis of online discourse has also suggested different levels of epistemic questions and explanations, ranging from *low-level questions* (asking for basic facts or literal meanings) to questions *identifying inconsistencies and seeking for elaborations*. We also identified meta-questions that take account of what the group has advanced thus far and that made *idea improvement* more possible. For instance, the illustrative example shows that the student identified the state of the group discourse (e.g., "I see *most of you* are talking about the benefits of TQM") and considered different views ("But is TQM really suitable for China?"…). Specifically, this student questioned the appropriateness of TQM for Chinese businesses, thus deepening the state of the ongoing discourse by challenging its take-it-for-granted epistemology, treating ideas as improvable objects, thus opening up the room for more sophisticated explanations.

Students' responses were also coded in three levels to distinguish their depth of explanation: *simple claims*, *elaborated explanations* supported by reason, and *meta-explanation*, a rise-above explanation that takes into account the existing state of discourse. The illustrative example suggests how one student adopted a meta-explanatory perspective by synthesizing and elaborating on key points from previous group discussions—the ideas no longer belonged to an individual student, but emerged from the group as communal knowledge advances.

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> "As you said you didn't understand TQM very well, let me *explain* it according [to] my own words *from what we have discussed*. First, TQM is a way of management. Second, its aim is to get things right the first time. Then, the difference between TQM [and the traditional method is that] the traditional method [tries] to fix the mistakes but TQM tries to avoid mistakes." (*Note #18, emphasis added*)

Metacognitive reflection Metacognitive reflection refers to students reflecting on earlier and current states of understanding or actions. Three different levels of metacognitive strategies were identified: *meta-cognitive reflection* refers to statements relating to individual meta-cognition (e.g., "Now I see the connection"), including self-monitoring and reflecting, or to individual learning goals. *Regulation with others* was used to code statements indicating interaction and regulation in a group context (e.g., "I will bring my puzzlement to the group"), while *collective regulation* refers to statements indicating how students reflected on his or her understanding in light of group discourse. As shown in the example, the student reflected and changed her understanding in light of group knowledge advances; she monitored changes in both communal and individual understanding of TQM.

> "When I knew about TQM the *first time, I thought* it is a method of management that shows us how to get things right at the first approach; …*after…discussion with my partners*… TQM [emerged as] a kind of spirit to some extent… Our following investigations in the XX company *revealed …Only in this way can I connect* all the things I learnt together and get a systematic understanding of TQM…and the definition of TQM may differ from one another" (*Note # 110, emphasis added*)

Social dynamics Statements reflecting social and community dynamics include building rapport, making contribution, and working to include more ideas to community inquiry (Hakkarainen 2009; van Aalst 2009). These statements usually go beyond mere interaction and suggest a sense of community as students are concerned with bringing in ideas from other members to deepen the inquiry. Social dynamic statements used in the collaborative inquiry discourse also suggested that the collective knowledge building may have led to a harmonious and constructive culture (e.g., "I think we should be one. We need to support each other").

The first author coded all computer entries and to obtain inter-rater reliability, an independent rater coded 25 % of online discussion notes. Cohen's Kappa was computed to measure the agreement (De Wever et al. 2005; Krippendorff 2004), yielding values of .77 for conceptual processing, .78 for problem-solving, .80 for metacognition, .82 for questioning, .77 for explanation, and .86 for social dynamics.

Quantitative discourse analysis

Differences between high- and low-performing groups A quantitative analysis was conducted to examine group differences in the identified discourse moves. Table 6, 7, and 8 shows the frequencies of the identified discourse moves among high- and low-performance groups. To ensure the valid comparison of discourse moves across groups, the frequency of occurrence was divided by the total number of group notes written to reveal the percentage of notes in which each discourse move occurred. For example, Group 1 contributed a total of 36 notes, of which 28 (77.78 %) coded conceptual processing; 11 (30.56 %) indicated problem solving; 23 (63.89 %) pertained to epistemic questions, respectively etc; Group percentage scores were employed for individuals in the group, based on the notion

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t6.1 **Table 6** Coding categories, definitions and exemplar notes

	Coding categories	Definition	Examples
t6.2	Coding categories	Definition	Examples
t6.3	1. Conceptual processing		
t6.4	Paraphrase	Copy and paste from textbook with little processing	*TQM is an organizational management approach for making all individuals responsible for improving quality of goods and services supplied. (Note #14)*
t6.5	Elaboration	New information treated problematic for elaboration	*What is TQM? Maybe it is a kind of management to keep all products perfect quality and…it is a good method to avoid quality accidents. (Note # 16)*
t6.6	Collective processing	Examine—information from different perspectives to synthesize views and advance collective understanding	*It seems that each holds a difference of opinion of TQM. A said TQM is some kind of spirit thing that exists in own mind. It is a(n) idea and B agreed. C disagreed and insisted that it is a tool…After* ***[considerable] reading*** *and* ***online discussion*** *we* ***came to [see]*** *that TQM was something that felt like a spirit. It was something mental* ***because****…. (Note #112)*
t6.7	2. Problem solving		
t6.8	Surface task-based	Take project simply as completion of several mini-tasks	*The conclusion of interview questions: Question 1,2 from A; Question 3–6 from B; Question 7,8 from C (Note # 533)*
t6.9	Information-sharing	Provide useful information for project work	*A brief introduction to XX company. XX company were founded in … (Note #119)*
t6.10	Collective problem-solving	View project as a collective problem-driven inquiry into a real business context; focus on group efforts in solving problems	*…And I am totally* ***confused with all the concepts*** *and definitions of TQM. Then,* ***we started*** *to thing (think) to visit a company first…but which company should we pay a visit to****? We agreed*** *that this company should at least have a complete management system and it would be better if it produces real goods not service. …(Note #113)*
t6.11	3. Epistemic inquiry—questioning		
t6.12	Factual / clarification	Questions on basic facts, literal meaning of a sentence, asking for help or clarification	*I don't know (what is) the meaning of this sentence… (Note #24)*
t6.13			-
t6.14	Identifying inconsistencies	Questions identifying inconsistencies for explanation	*Why do we (Chinese businesses) need TQM? (Note # 117)*
t6.15	Seeking to improve ideas	Questions raised to seek to improve community ideas	*Yes,* ***I see most of you*** *talking about benefits of TQM. (But) is TQM really suitable for China? The fundamental of TQM lies in improving the quality. However, Chinese traditional logic influences this so deeply and widely. To completely change the situation and make every staff involve is very difficult… (Note # 213)*
t6.16	4. Epistemic inquiry—explanation		
t6.17	Simple claim	Give opinion without explanation or with irrelevant cut-and-paste information	*Yes, I think TQM is very important for foreign countries, but it isn't suitable for a Chinese company. (Note # 213)*

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t6.18 **Table 6** (continued)

	Coding categories	Definition	Examples
t6.19	Elaborated explanation	Make a claim supported with reasons, evidence and examples	*There is a significant difference between TQM and Quality Control. TQM is about a continuing process of improvement involving all aspects of the business… On the other hand, Quality Control is just one aspect of the process. (Note # 123)*
t6.20	Meta-explanation	Explanation based on what the group has discussed previously to further inquiry.	*As you said you didn't understand TQM quite well, let me explain it according to (in) my own words from* ***what we have discussed****. First, TQM is a way of management. Second, its aim is to get things right the first time. Then, the differen(t) ce between TQM and the traditional method try to fix the mistakes but TQM try to avoid mistakes. (Note #18)*
t6.21	5. Metacognitive reflection		
t6.22	Metacognitive-individual	Checking own progress and understanding;	*(The passage I read.) It answered four questions. These answers help me know more about ISO 9000. I couldn't understand why teachers mentioned ISO 9000 when talking about TQM. Now I see the connection (Note#513)*
t6.23		Identifying changes by reflecting on understanding and actions;	
t6.24	Regulation with others	Control and adapt strategies as a result of interactions with group members; learn in conjunction with others	*There is still one principle I cannot understand well about Mutually Beneficial Supplier Relationships. And I will bring this doubt to the class and solve it by my efforts. (Note #9)*
t6.25	Collective regulation	Reflect on how group processing contributes to changes in personal understanding and group inquiry	*When I knew TQM the first time. I thought it is a method of management that shows us how to get things right at the first approach. …****after [some] discussion with my partners****, … TQM is a kind of spirit to some extent…Our following investigation in the XX company revealed…* ***Only in this way can I connect all the things*** *I learnt together and get a systematic understanding of TQM. And the definition of TQM may differ from one to another." (Note # 110)*
t6.26	6. Social dynamics		
t6.27		Statements for building up rapport; and bringing in community ideas to facilitate inquiry	*I think we should be one. We need to support each other. (Note # 12)*
t6.28			*The company (we investigate) is a printing company. We can't focus on every TQM principle. How about we focus on the process approaches because…(Note # 422)*

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t7.1 **Table 7** Frequencies and percentages of the identified discourse moves between high-and low- performance groups

		High-performance groups								Low-performance groups							
t7.3		Group 1 (*N*=5)		Group 3 (*N*=5)		Group 4 (*N*=5)		Group 7 (*N*=4)		Group 2 (*N*=5)		Group 5 (*N*=5)		Group 6 (*N*=5)		Group 9 (*N*=5)	
t7.4	Number of notes	36		28		69		15		39		33		22		21	
t7.5		f	%	f	%	f	%	f	%	F	%	f	%	f	%	f	%
t7.6	**1. Conceptual processing**	**28**	**77.78**	**16**	**57.14**	**47**	**68.12**	**15**	**100**	**24**	**61.54**	**21**	**63.64**	**10**	**45.45**	**19**	**90.48**
t7.7	Paraphrasing	3	8.33	7	25.00	12	17.39	1	6.67	12	30.77	6	18.18	2	9.09	6	28.57
t7.8	Elaboration	21	58.33	9	32.14	29	42.03	13	86.67	12	30.77	15	45.45	8	36.36	13	61.90
t7.9	Collective advances	4	11.11	0	0.00	6	8.70	1	6.67	0	0.00	0	0.00	0	0.00	0	0.00
t7.10	**2. Problem-solving**	**11**	**30.56**	**7**	**25.00**	**32**	**46.38**	**2**	**13.33**	**7**	**17.95**	**11**	**33.33**	**5**	**22.72**	**7**	**33.33**
t7.11	Surface task-based	0	0.00	0	0.00	0	0.00	0	0.00	2	5.13	3	9.09	4	18.18	5	23.81
t7.12	Information-sharing	3	8.33	2	7.14	5	7.25	0	0	5	12.82	7	21.21	1	4.55	2	9.52
t7.13	Collective problem-solving	8	22.22	5	17.86	27	39.13	2	13.33	0	0	1	3.03	0	0	0	0
t7.14	**3. Epistemic inquiry questioning**	**23**	**63.89**	**16**	**57.14**	**22**	**31.88**	**2**	**13.33**	**20**	**51.28**	**6**	**18.18**	**2**	**9.09**	**8**	**38.10**
t7.15	Factual/ clarification	3	8.33	3	10.71	6	8.70	0	0.00	14	35.90	2	6.06	0	0	2	9.52
t7.16	Identifying inconsistencies	9	25.00	8	28.57	12	17.39	2	13.33	1	2.56	4	12.12	2	9.09	3	14.29
t7.17	Seeking to improve ideas	11	30.56	5	17.86	4	5.80	0	0.00	5	12.82	0	0.00	0	0.00	3	14.29
t7.18	**4. Epistemic inquiry-explanation**	**33**	**91.67**	**15**	**53.57**	**33**	**41.83**	**8**	**53.33**	**15**	**38.46**	**10**	**30.30**	**11**	**50**	**5**	**23.81**
t7.19	Simple claim	11	30.56	3	10.71	9	13.04	0	0.00	9	23.08	3	9.09	3	13.64	1	4.76
t7.20	Elaborated explanation	19	52.78	12	42.86	21	30.43	8	53.33	6	15.38	7	21.21	8	36.36	4	19.05
t7.21	Meta-explanation	3	8.33	0	0.00	3	4.35	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
t7.22	**5. Metacognition**	**20**	**55.56**	**17**	**60.72**	**26**	**37.68**	**8**	**53.33**	**19**	**48.72**	**14**	**42.42**	**8**	**36.36**	**3**	**14.28**
t7.23	MC-individual	5	13.89	7	25.00	5	7.25	2	13.33	7	17.95	9	27.27	5	22.73	0	0.00
t7.24	Regulation with others	7	19.44	5	17.86	13	18.84	1	6.67	10	25.64	4	12.12.	1	4.55	2	9.52
t7.25	Collective-regulation	8	22.22	5	17.86	8	11.60	5	33.33	2	5.13	1	3.03	2	9.09	1	4.76
t7.26	**6. Social dynamics**	**16**	**44.44**	**9**	**32.14**	**19**	**27.54**	**2**	**13.34**	**5**	**12.82**	**4**	**12.12**	**0**	**0.00**	**1**	**4.76**

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Table 8 Means of the frequencies and percentages of the high-level discourse moves between high- and low-performance groups

	High-performance groups		Low-performance groups	
	Frequency	Percentage	Frequency	Percentage
Collective processing	2.84	6.62	.00	.00
Collective problem-solving	10.97	23.65	.25	.76
Meta-question	5.26	14.20	2.00	6.78
Meta—explanation	1.58	3.30	.00	.00
Collective regulation	6.58	20.62	1.50	5.50
Social dynamics	11.5	29.37	2.50	7.43

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that discourse moves emerge collectively in a group rather than belonging to each individual (Stahl 2006).

As the goal was to capture collective inquiry and for reasons of coherence, group comparison analyses were conducted on higher-level discourse moves in the major categories, namely collective processing; collective problem solving; meta-questions, meta-explanations, collective regulation and social dynamics. There were four or five students in each group and they were given the same scores for the computer entries as these discourse moves belonged to the whole group not the individual. To correct for different sources of errors, we have set the alpha level at a more stringent level (.01) for statistically significant differences. Non-parametric tests using Mann-Whitney U tests comparing high-performing and low-performing groups on percentages of high-level discourse moves indicated significant group differences on collective processing ($Z=-4.60$, $p<0.001$), collective problem solving ($Z=-5.76$, $p<0.001$), meta-explanation ($Z=-3.67$, $p<0.01$); collective regulation ($Z=-5.38$, $p<0.001$), and social process ($Z=-5.38$, $p<0.001$). Group differences on meta-questions were not significant at 0.01 level. Primarily, the results indicated that high-performance groups employed more meta-discourse and social dynamics moves than low-performance groups during collaborative inquiry mediated by Knowledge Forum.

Relationships between collective discourse moves and academic learning Further analyses were conducted to investigate the relationships between collective processing discourse moves with students' individual performances on academic literacy. As the students were nested within groups, it would be more appropriate to use multi-level modeling analyses. However, due to problems with the sample size, the students in a given group were given the same discourse scores, as collective discourse moves emerged from the group rather than its individual members, an approach that has been employed in other CSCL studies (*e.g.*, see Jassen et al. 2012). Statistical significant level was set at a more stringent level of 0.01. Correlation analyses show that academic literacy was related to collective processing in conceptual learning ($r=.48$, $p<.002$), collective problem solving ($r=.45$, $p<.004$), meta-explanation ($r=.44$, $p<.005$), and social dynamics ($r=.50$, $p<001$). Correlation of collective regulation ($r=.37$, $p<.02$) was not significant at 0.01 level. Overall, these results indicate that meta-discourse and social dynamics moves were correlated with individual academic scores: students working in groups that made more collective discourse moves also tended to have higher academic scores (Table 9).

Table 9 Correlations between collective processing moves and academic literacy

	1	2	3	4	5	6	7
1. Collective processing	-						
2. Collective problem- solving	.78**	-					
3. Meta- question	.36 *	.27	-				
4. Mea-explanation	.88 **	.67**	.63**	-			
5. Collective regulation	.62 **	.47**	.21	.34**	-		
6. Social dynamics	.69**	.74**	.73**	.78 **	.49**	-	
7. Academic literacy	.48**	.45**	.17	.44**	.37*	.50**	-

* $p<0.05$; ** $p<0.01$

Example of student online discourse

To provide more information on how knowledge building dynamics are manifested, we examined an example from students' online discourse on Knowledge Forum. In this example of collaborative knowledge building inquiry, students were working together to build knowledge concerning Total Quality management (TQM). The teacher did not set prescribed problems but allowed the students take up agency as they pondered about different theories and questions. One student started with writing:

Q60

> My theory maybe it is a good method to avoid quality accident because TQM guarantees highest quality… (*S#6*)

S#6 started with posing his idea about TQM; he did not provide a definitive answer but conjectured a tentative idea to be improved. He employed an epistemic stance using words such as 'maybe' making room for others to build on for improvable ideas.

> Different theory I don't understand it clearly, but I think it is a way to examine the product. If the product is up to TQM's standard (see the article attached), the product is good. (*S#7*)

S#7 continued and engaged in a metacognitive mode, noting that what he did not know clearly. He put forth another possible idea and explanation for TQM, and refers to another source of information to broaden the community resources. The acknowledgement of uncertainty and adding resources reflect epistemic agency and opened up venue for group advances and idea improvement.

> let me explain Elaboration Hi Sam! As you said you didn't understand TQM very well, let me explain it to you according [to] my own words from what we have discussed. First, TQM is a way of management. Second, its aim is to get things right at the first time. Third, the difference between TQM [and the traditional management method is that] traditional methods [tries] to fix the mistakes but TQM tries to avoid mistakes. (*S#8*)

S#8 joined the discussion with a sense of community as students saw the need to work together. S8 was not just concerned about her own understanding but how she could contribute to others as she took up group ideas. Social and communal elements were important for knowledge building as the student tried to explain the ideas to others for advancing together. As the discourse proceeded, the idea of TQM was becoming richer.

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> Different theory TQM, to me is an approach to organize all processes. And it needs each individual at each level to work properly towards the same goal…. (*S#9*)

The discourse did not stop after this elaborate explanation; another student posed her ideas provoking further thoughts.

> I couldn't understand An approach to organize process? A tool to control quality? What is it? It is so confused [confusing]. (*S#10*)

S#10 was taking up what other group members had discussed thus far about TQM as a tool and as an approach to organize process, and from there, she posed further questions. In this community, students built on group discourse and they were ready to pose questions and to acknowledge inconsistency and problems. Students checked their understanding with others' models, which sparked further advances. Posing questions brings about explanation that opens room for improving ideas. Another student wrote:

> some fresh thoughts about TQM Evidence Today I read an article and one sentence caught my attention. "TQM is not a system, a tool or even a process. Systems, tools and processes are employed to achieve the various principles of TQM." My theory at the first time. I thought it is a method of management that shows us how to get things right at the first approach. So there must be a set of standard TQM system to follow. However, there is no standard TQM. *After [some] discussion with my partners*, I have my own understanding: TQM is a kind of spirit to some extent… Elaboration It is a spirit [philosophy] through out the whole organization… from the product assemble line to the customer service. In the manufacture session, TQM is aimed at producing the goods with the lowest defects or without defects. In the after-sale session, TQM is targeted at enhancing customer satisfaction. Elaboration ***Only in this way can I connect all the things*** *I learnt* ***together*** *and get a systematic understanding of TQM. And the definition of TQM may differ from one to another."* (*S#8*)

S#8 used the title 'some fresh thoughts about TQM'. As students were reading and writing notes on Knowledge Forum and interacting with others, they articulated and reframed their ideas. S#8 reflected on her earlier understanding about what TQM is about and then noted explicitly that after discussion with her partners, she developed new ways of thinking about TQM. She is engaging in some kind of meta-discourse synthesizing different ideas from her peers (tools, processes) and rise above to a higher-level idea of spirit (philosophy). She also mentioned about bringing different ideas together that helped her learn. The example suggests how individual and collective understanding might evolve together and how epistemic agency and community dynamics may enhance metacognition and conceptual learning.

Such findings were also corroborated with evidence from interview data (to be reported in another study). Interview data suggested further differences in the environments. A knowledge-building student said, "In Knowledge Forum, we need to build on each other [and] the scaffolds and the structure of notes show us how the discussion develops. Good discussions in our group contained different ideas and useful questions, *provoking further discussion.* " (*Student #2, Group #1*). In contrast, a student from the project group remarked, "We usually talked online when we needed to make a big decision or when our leader informed us of emergencies, such as changed interview times or task deadlines. Decisions could be made when all the members had presented their opinions and voted on the best solution. It was very efficient. (*Student # 7, Group #4*)

The discourse example suggests that students' epistemic agency putting forth conjectures for idea improvement, raising questions and acknowledging gaps in understanding; comparing

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different ideas to spark inquiry; contributing to others and engaging in meta-discourse weaving personal and group ideas. Such discourse patterns might facilitate the construction of coherent understanding and explain how they might enhance both community knowledge and individual learning. While CKB students emphasized how Knowledge Forum helped them pursue inquiry and how ideas provoked further discussion, the RPL students also saw computer technology as important. However, their use thereof was superficial, limited to basic knowledge sharing, routine decision-making, and communications to enhance work efficiency and group harmony. While this may enhance interaction, it contributed little to deep inquiry and collective growth.

Discussion

This study examined CSCL design, collaboration and learning and investigated both collective knowledge-building dynamics and individual learning in the context of a tertiary education course in mainland China. Specifically, we examined how principle-based knowledge-building design would bring about knowledge-building collective dynamics that in turn influences individual learning outcomes. The results indicated the benefits of knowledge building in terms of academic learning than those of comparison groups, and that Knowledge Forum participation contributed to academic performance, after controlling for students' prior achievement. Analyses of discourse moves indicated that high-performance groups engaged in more collective moves than did low-performance groups, and that collective moves were related to individual academic learning. Issues related to CSCL practice pertaining to instructional effects, collective and individual learning, and design implications are discussed in the following sections.

Effects of CSCL: Role of knowledge-building environment on academic learning

Although project-based learning and computer-supported inquiry learning have been both widely recognized and advocated as useful and innovative instructional approaches in higher education (Helle et al. 2006; Strijbos et al. 2004), there has been a dearth of studies in the extant literature that provide analyses and evidence of *both* collective process and individual learning effects. This study contributes to CSCL literature in higher education on the alignment of design, collaboration and learning through both quasi-experimental design and discourse analyses. The study used comparison groups, utilizing multiple data sources, to illustrate the benefits of a collaborative knowledge-building design in higher education in mainland China. Analyses of pre- and post-test questionnaires, writing quality and online discourse have provided evidence to demonstrate that the knowledge-building inquiry design fostered the students' deep cognitive, metacognitive and social processes and enhanced their conceptual understanding and literacy.

The effects of knowledge-building designs on academic performance have been demonstrated through analyses across and within groups. In addition to group differences, within-group server-log results have given further support to the role of Knowledge Forum engagement—it was not only how many notes the students wrote, but also their use of scaffolds that correlated with academic literacy. The scaffolds helped the students to develop epistemic agency and signal the social intent of the posting to others in the community. This finding is consistent with current knowledge-building literature on the role of scaffolding in shaping knowledge-building discourse and promoting "social meta-cognition" (Scardamalia and Bereiter 2006). Regression results indicated further that Knowledge Forum engagement

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contributed to academic literacy above and beyond academic ability and beliefs about collaboration, while qualitative analyses illustrated that discourse processes and specifically collective moves were correlated with academic performance. This study has moved beyond merely examining the effectiveness of the designed environment in promoting learning and collaboration to gain more insights into knowledge building dynamics, as mediated by the design and the use of technology.

Extant research on technology use in higher education has often reported gains in motivation, self-confidence, and self-directed learning (*e.g.* Hmelo-Silver 2004), and CSCL research has made significant progress examining collaboration dynamics (Hmelo-Silver 2003; Muukkonen and Lakkala 2009; Puntambekar et al. 2011; Stahl 2006). This study has suggested that an inquiry design mediated by technology informed by knowledge building principles has the potential to promote both collaborative dynamics and individual learning, including conceptual understanding, explanation-argumentation, and more sophisticated beliefs about collaboration. These findings also enrich knowledge-building inquiry and CSCL literature, especially in literacy studies (Yeh *et al.* 2011). While the knowledge building theoretical framework emphasizes collective advances, this study's findings support the contention of Scardamalia and Bereiter that *learning and literacy development can be by-products of collective knowledge building*. Earlier research has been conducted largely in science and, occasionally, literacy of elementary students. This study extended the line of inquiry into Chinese tertiary students' indicating the positive effects of knowledge building on students' understanding of business concepts and academic literacy development. In terms of CSCL in practice, it is important to demonstrate that CSCL effects can be diffused to individuals; these findings also shed light on potentials of CSCL research examining both processes and effects.

Collective knowledge-building discourse moves and individual learning

This study examined collaborative processes contributing to individual learning and developed a multi-dimensional scheme, identifying several patterns including conceptual, epistemic, metacognitive and social dimensions. While many CSCL coding schemes have included conceptual, metacognitive and social processes, we have identified elements of collaboration oriented to collective dimensions. Discourse analyses illustrate that student groups vary from surface-moves (disconnected information) to making some elaboration to *meta-discourse integrating and examining different ideas arising from the group discourse;* ideas no longer belong to an individual, but emerge collectively from within the group. Different levels of conceptual knowledge processing were categorized, ranging from paraphrasing and elaboration to collective processing that resemble some rise-above efforts. Similarly, levels of problem solving were identified from surface task division, information sharing to a higher level of collective problem solving. Metacognitive processing and collective regulation suggest that students reflect on and regulate their progress in relation to group advances, and that, they engage in meta-discourse using meta-explanation to bring together different ideas from peers as they move towards a more collective viewpoint. Social dynamics have been described as important in knowledge-creation discourse (van Aalst 2009), and students' emphasis on social and community elements can facilitate bringing in more diverse ideas for collective inquiry.

In comparison with their counterparts, the high-performance groups made more collective discourse moves, including collective processing, collective problem solving, collective regulation, and social dynamics. Contrastive group analyses suggested that the successful groups might have been taking up more collective goals and dynamics rather than working individually or using division of labor in a group context. Meta-discourse that involves taking stock of

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what the group has discussed and inquiry into current state of collective knowledge may spark further inquiry. These analyses are consistent with the framework of knowledge-building discourse emphasizing meta-discourse and community knowledge (Scardamalia and Bereiter 2006; van Aalst 2009) and highlight the educational significance of collective dynamics in CSCL.

A key contribution is the observed relationship between online collective processing discourse and individual learning performance. Student groups engaging in meta-discourse also scored higher in their individual learning. Analyses of the knowledge building discourse example suggest how students' work together with sense of group/community contributing to each other's understanding. Students pose ideas that need improvement conjecturing and pondering and acknowledging difficulties. As they take up each other's ideas, they weave between individual and group understanding. Apparently, CSCL student teams often explain to each other in online discourse, but here it is explicit in knowledge-building design that students engage in collective cognitive responsibility; they compare and synthesize different ideas, reflect on how group members have contributed, how ideas evolve and how they connect different ideas together.

While the students were working collectively, focusing on group goals and communal advances (not just personal learning), they were more likely to engage in co-regulation and become more reflective of knowledge gaps as they monitored their own and group understanding. Possibly students might move from fragmented to improvable and collective ideas; they brought together different views from group-mates taking ideas to higher levels; these might necessarily bring about deeper processing, improvable discourse and diffusion of knowledge distributed to individuals in the groups. While substantial studies in CSCL and knowledge-building literature have characterized conceptual, metacognitive and social processes leveraged by technology (e.g. Muukkonen and Lakkala 2009; Pifarre and Cobos 2010), the links between socio-cognitive and collective dynamics and students' academic performance have not been established clearly empirically, especially in tertiary education settings. This study is one of the few to document the connection between collective processing discourse moves and individual academic gains. It has provided useful evidence that student engagement in knowledge building, and in particular, collective, meta-discourse is related to academic learning.

Generally, these findings could contribute to the ongoing discussion on learning across levels in CSCL: There appears to be a need to examine both discourse processes and individual learning to establish that collective CSCL can benefit the latter; and to examine how collective and individual learning evolve. Such theoretical questions seem particularly worthy of investigation in different cultural settings (*e.g.*, Asian classrooms) where academic learning plays an important role. Given CSCL's ongoing endeavors to develop practice in classrooms, these international endeavors such as pioneering studies in China may help to address the links among design, process and learning. For design implications, these findings highlight the importance of scaffolding students to make rise-above and to reflect on the knowledge advances of the group (community) for improvable discourse and inquiry. Specifically, students could be encouraged to engage in meta-discourse and reflect on group advances, noting explicitly what has been discussed and how ideas have progressed. Future investigation can be conducted to test whether helping students to engage in meta-discourse moves may enhance collective and individual knowledge advances.

Design for knowledge building pedagogy in tertiary classrooms

This study has also shed light on CSCL design and pedagogy. A knowledge-building environment emphasizing several principles was designed in this study to address the socio-

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cultural and educational context of China. In terms of alignment and fidelity of implementation, generally, the discourse patterns and analyses derived from this study have provided evidence to suggest that the students were influenced by the designs and principles; they displayed collective moves and social dynamics, and were concerned with community advances in their discourses in Knowledge Forum. Similar to previous studies that test the effects of scaffolds (Scardamalia et al. 1994), this classroom-based study also show that the use of scaffolds is correlated significantly with academic learning. Furthermore, analyses of discourse demonstrated how the scaffolds as epistemic markers support students in pursuing questions and explanations; how the emphasis on principles of collective cognitive responsibility brings about meta-discourse as students reflect on both personal and group advances. Such observations suggest the importance of aligning design with analyses; as the goal of design is knowledge building, students' discourse is to be examined from the perspective of collective moves. More analyses are needed to investigate how novice students develop more mature practice of knowledge building discourse to inform the future design of the learning environment.

This study has also suggested how CSCL pedagogy and technology can be designed to influence student learning and collaboration in higher education settings. Primarily, the environment was designed informed by principles, its discourse suggesting collective advances, which might demonstrate a degree of alignment between the way in which technology is actually used and underlying design principles that emphasize epistemic agency, improvable ideas, and community knowledge (Scardamalia and Bereiter 2006). This finding supports the argument that the effective use of CSCL technology in teaching and learning must not rely merely on technological devices or media, but on pedagogical philosophies and principles (Scardamalia and Bereiter 2006). Several design implications for knowledge building and academic literacy development are outlined as follows:

The first is that design work should be directed at facilitating collective cognitive responsibility. This is different from the traditional division-of-labor approach to task completion. At the preparatory stage, classroom and online activities should be designed to cultivate a democratic culture in which students may express ideas openly and freely, and respond to and explain to each other to advance communal knowledge and understanding. For example, to encourage students to migrate to, engage in and contribute to online inquiry discourse, specific classroom and online activities, such as online jigsaw reading and writing, could be used to enhance the diversity of ideas and depth of questions and explanations, and to co-construct new understanding. In addition, such activities optimize both the input and output language of the discourse community, which is essential for English literacy development. The purposes of such scaffolding activities should be explained in full to the students, as this may promote meta-cognition and collective cognitive responsibility for collaborative inquiry.

The second consideration is that design work should aim to create an environment that fosters epistemic agency—in this study, for example, students used scaffolds to raise questions, articulate difficulties, design their own work, and so on. Teachers should believe in and empower students' epistemic agency. Design work should focus on ideas and deep understanding rather than tasks, form or declarative knowledge. Activities informed by principles, whether in class or online, should be designed to encourage ideas, questions and inquiry in order to develop in-depth understanding. Even in the constrained and highly competitive environments of Chinese tertiary classrooms, this study suggests the possibilities of having students work collectively towards epistemic agency.

The third design consideration is that the learning environment should involve authentic problems, real ideas and improvable ideas. Interactions with the outside community, where authentic problems and ideas are embedded and from which authentic social norms and

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practices can be appropriated, should be encouraged. This provides ample opportunities for integrating concept learning with project inquiry (similar to fieldwork or experiments in science) to foster deeper understanding, identify knowledge inconsistencies between theories and practices, reflect upon knowledge gaps and different models generated by the inquiry communities, and collectively advance knowledge frontiers.

These principles, focusing on epistemic agency, community knowledge and improvable ideas mediated by the socio-cognitive and technological dynamics of Knowledge Forum, have been examined in Western educational systems, often in the context of elementary schools (Zhang et al. 2007, 2009). Based on its design and the analysis of its findings, this study has suggested the possibility of examining and fostering a collaborative inquiry knowledge-building design in the Chinese tertiary education context and other places new to CSCL.

Limitations of study

As do most classroom-based studies, this study faced challenges arising from the complexity of real-world classroom situations that make it difficult to control variables as strictly as in laboratory studies (Brown 1992; Collins et al. 2004). The instructional effects observed may not be attributed to specific key elements of the design, such as the use of forum separately, but must be attributed to the overall design of the environment underpinned by the design principles (Scardamalia and Bereiter 2006). This is different from a laboratory study, where different contributing factors need to be delineated and examined. It is useful to note that while there may be concerns with teacher biases, all classes (including comparison) work on a joint program with a UK university with similar assessment standards so high-quality instruction is required. As noted before, this study goes beyond inter-group comparisons and extensive qualitative discourse analyses using multiple methods included to explain the effects illuminating the processes. We acknowledge the complexity of classroom research and more attention can be given to methodology for CSCL classroom research.

A second limitation lies in how close the design is to a strong form of knowledge building environment. As it was the first time tertiary business students in mainland China had experienced a collaborative knowledge-building, the design is not very sophisticated and opportunistic and emerging aspects are clearly lacking, but it is generally relevant to specific social-cultural contexts. As an initial step in classroom-based design research, this study used a fixed group design rather than focusing on an emergent and opportunistic knowledge-building community (Zhang et al. 2009). Considering that the participating students were new to knowledge-building pedagogy, efforts were made to transform their extant individual learning culture into a group-oriented collective climate. Further design research could stress fostering knowledge-building cultural capacity and a sense of community, as well as knowledge-creation dynamics and discourses.

Another limitation concerns the analyses and sample size. As the study had a specific goal of examining relations between discourse moves and individual learning, we focused on the approach of coding individual computer notes identifying meta-discourse moves rather than going into analyses of how discourse unfolds, but it is important to note that emergent approaches to analyzing inquiry threads should also be adopted in future for collective knowledge-building dynamics. We did provide a discourse example that provides glimpses on how collective and individual understanding evolves but further work is needed to illuminate such processes. Furthermore, a major limitation is that sophisticated multi-level modeling analyses would be more appropriate for exploring the relationship between collective group processing and individual learning outcomes, as the students were nested in groups. However, due to the limited number of participants, a much simpler analytical procedure had

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to be used. Despite the acknowledged limitation, this study can, nonetheless, serve as a basis for more sophisticated instructional design and analyses in future, larger-scale studies to confirm its findings.

While it is important to acknowledge its limitations and difficulties, the study's methodological approach aligns with its research objectives of examining both collaborative processing and individual learning in complex classroom setting. Similar to classroom intervention studies using technology, where many variables cannot be controlled easily, this study went beyond group comparison; it addressed the problem of designing and examining the role of the knowledge-building environment and has raised further questions about the possible links between collective and individual learning.

Conclusions

In conclusion, this study has several contributions and implications: First, it has furthered our understanding of *CSCL practice* providing evidence about both CSCL processes and CSCL effects with classroom research into CSCL design, collaboration dynamics and learning outcomes. The study has documented the effectiveness of a principle-based knowledge-building approach to promote collaborative inquiry and academic literacy among Chinese tertiary students; multiple methods were employed, highlighting the need to consider both CSCL processes and effects. Second, this study has contributed to our theoretical understanding in CSCL, providing some evidence of the links between *collective discourse and individual learning*. While many coding schemes include conceptual, collaborative, metacognitive and social dimensions, we have identified discourse moves oriented to collective dimensions and meta-discourse in the group; these processes are linked to individual learning and aligned with the goal of collective advances in the knowledge-building designs. The pedagogical implications are that students can engage in meta-discourse explicitly reflecting on what the group has discussed and what group advances have been made for rise-above and further inquiry. Third, this is one of the pioneering CSCL studies conducted in mainland China; the appropriation of *design* suggests how CSCL pedagogy can be transformed, addressing distinctive social-cultural and epistemological practices, to achieve the educational goals of collaboration and learning among tertiary students. This study may generate new discursive understandings of how tertiary students may move towards higher-level collaborative inquiry in a technology-enhanced knowledge-building culture. Many questions remain to be addressed about CSCL in practice relating to the alignment of design, collaboration and learning, but these findings may provide researcher, educators, designers and policy-makers with a useful basis for CSCL classroom innovation in different cultural settings.

Acknowledgments We would like to thank Dr. Jan van Aalst from the University of Hong Kong as well as the anonymous reviewers and the handling editor for their helpful comments and constructive suggestions on earlier drafts of this article.

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