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A Conceptualization of Factors Affecting Collaborative Knowledge Building in Online Environments

ABSTRACT

Purpose: The purpose of this review was to address the major findings of published research on the factors influencing students' knowledge building in an online collaborative environment.

Methodology: The Preferred Reporting Items for Systematic Reviews and Meta Analyses (PRISMA) was used to review and synthesize existing empirical studies on knowledge building in a collaborative learning context. Twenty-four studies were identified from major electronic bibliographic databases. The research was conducted between 2017 and 2019. Results of these studies were analyzed to determine potential factors that may influence the knowledge building process among students. **Findings:** Factors related to interaction and participation, task, student, and support were found to be the major factors driving students' knowledge building in the online collaborative learning environment. The association between these factors and certain collaborative tasks was mapped.

Values: Findings from this review can help decision makers of higher education in both developing and developed countries to take the necessary steps in order to promote effective knowledge building practices in online collaborative learning. It may also help educational policy makers to understand the particulars of collaborative knowledge building practices, so to increase organizational overall effectiveness and performance.

Keywords: computer-mediated communication, collaborative learning, distributed environments, knowledge building

INTRODUCTION

The recent movement of educational policy makers to encourage students to engage in effective knowledge building activities has resulted in various societal, economic, and environmental problems that are still emergent and not well studied (Csikszentmihalyi and Wolfe 2014, Lai and Campbell 2018). Thus, it is important that students develop their intellectual skills such as critical thinking, creativity, problem-solving, and collaboration in order to effectively deal with these problems (Lin, Chang et al. 2017, Al-Samarraie and Saeed 2018). Since collaborative learning activities are consistent with a sociocultural perspective (where knowledge is socially constructed), individuals can share knowledge and tackle communication losses with other individual group members (Ioannou, Demetriou et al. 2014). In the current knowledge society, collaboration between members has become an essential element for ensuring effective knowledge building practices. Veerman (2001) defined collaborative learning as a pedagogical process that encourages students to discuss problems and viewpoints from different perspectives and to elaborate and refine their understanding to build new knowledge.

One of the most important areas of collaborative learning is the use of advanced technologies to support various collaboration and sharing scenarios (Stahl, Koschmann et al. 2006). An influential example of an institutional model using computer-supported collaborative learning (CSCL) technology is “knowledge building”, also known as knowledge creation, which is defined as “the production of knowledge that adds value to the community” (Scardamalia and Bereiter 2006). The notion of knowledge building has emerged as a promising pedagogical advance in online collaborative learning. Knowledge building is a collaborative process that deals with the production and improvement of ideas in a context specific situation. Within the knowledge building process, students treat new knowledge or information as something problematic that needs to be explained. Moreover,

the literature explained that knowledge advancement is the collective work shared between the members of a group, and that knowledge is improvable through discourse (Scardamalia 2002, Scardamalia and Bereiter 2006). Therefore, knowledge building has been characterized as "knowledge creation", a third metaphor for learning (Paavola, Lipponen et al. 2004) that integrates the "knowledge-acquisition" (cognitive) and "participation" (situated) learning metaphors.

There is increasing pressure to provide learners with the abilities to construct meaningful knowledge and become an effective member in the collaborative learning process (Sahni 2018). To address this issue, knowledge building theory has been used as a promising pedagogical approach to preparing students for online collaborative learning (Bereiter and Scardamalia 2003, Scardamalia and Bereiter 2006). This theory asserts the significance of creating knowledge jointly in a society, and describes what learners need to achieve in order to enhance their capacity to learn, mainly through discussion (Scardamalia and Bereiter 2006). Thus, it is anticipated that engaging students in a constructive discourse for the development of new knowledge is important in the collaborative context (Law, Yuen et al. 2011). Scardamalia and Bereiter (2006) indicated that the learning that accompanies the process of knowledge building involves sub-skills and socio-cognitive dynamics embedded in the foundation of other learning approaches. Furthermore, the current conceptualization of the knowledge building process consists of collective cognitive responsibilities and students' engagement within a community to create and share new knowledge that is supported by online forums (Lee, Lajoie et al. 2017). This understanding has evolved alongside the development of what is referred to as CSCL and Knowledge Forum. CSCL and Knowledge Forum are networked learning environments designed using socio-cognitive and socio-technological dynamics, particularly to support knowledge advances among members of the group (Stahl, Anderson et al. 2006, Balakrishnan 2015).

Based on these, it can be said that the primary aim of CSCL is to provide the ability for learners to fully engage in the community, as well as creating a new structure for social communication that is critical for supporting individuals' participation in the process of knowledge building (Yücel and Usluel 2016). This might result in different emergent processes and outcomes that may substantially influence the knowledge building process in an online collaborative learning environment. Previous studies on CSCL (e.g., (MacLeod and Yang 2018, Reis, Isotani et al. 2018) have identified and explained the role of various antecedents to the development of individuals' knowledge building through engagement of students in certain learning situations. Common aspects that have been studied in the literature usually consists of individuals' interaction (Cacciamani 2017), participation (Niu and van Aalst 2009, Naranjo, Onrubia et al. 2012, Yücel and Usluel 2016), complex reasoning and level of argumentation (Noroozi, Weinberger et al. 2013), metacognitive understanding (Cesareni, Albanese et al. 2008, Cacciamani, Cesareni et al. 2012), cognitive learning styles (Balakrishnan 2015), design processes (Lai 2015), regulatory processes (Järvelä, Malmberg et al. 2016), and motivational and scaffolding roles (Rienties, Giesbers et al. 2012). Despite these, there are still a number of challenges regarding the suitability of current learning and teaching approaches for building students' knowledge in a university context (van Aalst 2009, So, Seah et al. 2010). One of them is the pervasive conception that knowledge building activities are only suitable for students with higher cognitive abilities (Chan and Lee 2007). This belief has been commonly shared among research communities attempting to promote more student agency and responsibility in learning (So, Seah et al. 2010). For instance, Zohar and Dori (2003) argue that teachers with these fixed beliefs tend to use higher-order tasks for high-achieving students more often than for low-achieving students.

Furthermore, previous literature emphasizes that online interaction and participation are key drivers for the group members in the CSCL environment (Yücel and Usluel 2016). Although they are conceptualized differently by different researchers, interaction and participation have been treated as one dimension in many previous studies (e.g., (Hrastinski 2008, Chan and Chan 2011, Naranjo, Onrubia et al. 2012). This is because these studies considered interaction and participation as a basic component of the knowledge building process. The realization of participation is difficult without interaction, and similarly, it is expected that interaction occurs in an environment where there is an active participation by the group members. Other research evidence shows that the efficacy of collaborative learning depends on various conditions such as group composition (e.g., group size and gender), task features (e.g., task complexity and task design), and student characteristics (e.g., learning styles and attitudes). With regard to task characteristics, recent CSCL research suggests that a clear task structure is needed to foster cognitive processing and academic performance of the students (Schellens, Van Keer et al. 2005). Individuals are likely to be intrinsically motivated, if an effort is made to increase their feelings of competency and self-determination. Typically, these feelings can potentially be affected by specific task characteristics such as challenge level, degree of autonomy, and feedback. Furthermore, students are more likely to be motivated when they are actively involved in the learning process. According to Chae, Seo et al. (2015), complex and challenging tasks that enable students to decide how to carry out a learning task are more likely to encourage intrinsic motivation in students, thus increasing their knowledge level and productivity. Nah, Mennecke et al. (2009) asserted that task complexity is an important dimension of collaboration and has been found to be an essential predictor of team performance in various contexts.

Regarding the importance of students' characteristics, the literature reveals little evidence to prove their effects on students' knowledge building in a CSCL environment. Within the

online learning environment, the main concern of educational researchers is to equip students with competencies that are relevant to individuals' cognitive skills, social skills, meta-cognitive skills (Noweski, Scheer et al. 2012), creative problem-solving skills (Barron 2006), and design thinking skills (Lin, Chang et al. 2017). Hence, it becomes necessary to examine how design thinking in an online learning environment may influence students' knowledge-building argumentation and learning outcomes. Schellens, Van Keer et al. (2005) pointed to the importance of student satisfaction and attitude in facilitating knowledge construction in online environments. The literature also addressed the impact of certain facilitating strategies on students' learning in CSCL environments. For example, Collins and Berge (1996) identify the role of the tutor as instructor, moderator, and facilitator, which can potentially influence students' collaborative behavior. In addition, Garrison and Cleveland-Innes (2005) reported the importance of tutor's style of interaction and information management in facilitating students' learning in a CSCL setting. Sánchez-Alonso and Vovides (2007) found that certain facilitation strategies can help sustain students' knowledge building in online collaborative learning. The authors found that promoting students' meta-cognitive skills may play a key factor in increasing the efficiency of the online collaborative learning environment. Therefore, understanding the application of these dimensions is especially important for fostering online participation and the cognitive presence of the students.

Based on these observations, there appears to be a rich variation in previous studies in the field of knowledge building where more attention should be paid to make explicit the theories of collaborative learning in order to motivate students to learn effectively. There are currently no systematic reviews specific to collaborative knowledge building based on the factors (noted above) — participation/interaction, students, task, and support—that have been hypothesized in previous studies. Whereas many advances have been made in research on collaborative knowledge building (Scardamalia 2002, van Aalst 2009, Yücel and Usluel

2016), some important questions remain to be addressed: 'What are the key factors influencing students' knowledge building in a collaborative learning environment?' and 'What are the associations between these factors and certain collaborative learning activities/tasks?'. Thus, the purpose of the current review is to identify factors within the dimensions of participation/interaction, students, task, and support. In doing so, this review was designed to create a resource that will increase the capacity of and speed with which researchers can identify and incorporate these factors into ongoing research.

METHODOLOGY

A systematic review was conducted in order to show how various factors (categorized into participation/interaction, student, task, and support) emerged from different studies have contributed to the development of students' collaborative knowledge building in online context. This systematic review was conducted between 2017 and 2019. This study followed the Preferred Reporting Items of Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher, Liberati et al. 2009). The PRISMA method was used to ascertain precise and genuine search and retrieval of various studies on collaborative knowledge building in order to answer the research questions.

Search criteria

This review included empirical studies on collaborative knowledge building in higher education. All papers were either published in peer-reviewed journals, conference proceedings, or university repositories (online theses). Our review was guided by certain query filters as an efficient and effective strategy for retrieving relevant articles from different databases. We searched manually in nine electronic databases included those identified as relevant to online collaborative learning, information technology and social

sciences: ASSIA (Applied Social Sciences Index and Abstracts), Science Direct, EBSCO (consisting of Psychology and Behavioral Science, PsycINFO, SocINDEX, Library, Information Science and Technology Abstracts, CINAHL), ERIC (Education Resources Information Center), Emerald, Computer Society Digital Library (CSDL), ProQuest, Cochrane Library, Web of Science, and Scopus. Search terms were constructed in according to the focus of the current study, which include the following combinations: ("knowledge building") AND ("factors" OR "determinants" OR "identifiers" OR "construct") AND ("affect" OR "impact" OR "influence") AND ("collaborative learning" OR "online learning" OR "knowledge forum" OR "online discourse") AND ("higher education" OR "university students" OR "undergraduate students" OR "postgraduate students" OR "graduate students"). In essence, these filters helped us to lower the number of 'false positive' records found in the search of the literature, thus resulting in more efficient and accurate search process.

Screening and coding study records

A total of 1170 references were retrieved (see Figure 1) in which article record titles and abstracts were screened and retained for further review if they met two inclusion criteria: written in English and validated by at least one research design (qualitative/quantitative) to assess factors hypothesized to predict, influence or explain individuals' knowledge building in a collaborative context. The first hundred search results of every search were recorded and manually checked to determine their relevance for the selected topic. Then, multiple publications of the same databased were excluded because, according to Kitchenham and Charters (2007), duplicate research would seriously bias the results.

The initial screening result performed by the researchers led to the inclusion of 90 papers. Subsequently, retained full-text articles were further screened by the researchers based on the same two inclusion criteria utilized during screening of the article records with

additional criteria that the collaboration context is characterized by a well-defined activity (resulting in the exclusion of 69 articles). The remaining full-text of 24 articles were then reviewed in order to extract all factors hypothesized to influence the collaborative knowledge building process. It can be argued that strict exclusion criteria and paucity of literature on the topic of knowledge building may have contributed to the low number of included studies. This is supported by the work of Valentine, Pigott and Rothstein (2010) who stated that the strict inclusion and exclusion criteria on the topic of interest can contribute to the number of included studies. Furthermore, some previous reviews have been shaped based on a small number of studies (e.g., Broadbent and Poon 2015; Al-Samarraie, 2019) as a result of the selection criteria applied. The identified studies were carefully read by all authors in order to ensure that at least two reviewers read and evaluated each study. A second meeting was set up to compare notes and to reach agreement on factors identified in the previous meeting. As discussed in the introduction, the review of previous studies in the field of CSCL revealed four main categories: participation/interaction, student, task, and support. In the case of limited information on the design, context or activity, we directly contacted corresponding authors to gain a better understanding of these issues.

The coding of the factors in the screened studies was established by determining whether it included items assessing each of the four categories—participation/interaction, student, task, and support—as defined earlier. Factors were placed under the participation/interaction category if they assessed an individual's participation in an activity about which they shared understandings by interacting with other group members. Factors were placed under the 'student' category if they assessed constructs that represented behavioral and performance measures an individual experienced or achieved in the collaborative task. Factors were placed under the task category if they assessed constructs that represented aspects related to the design and nature of the learning task. Finally, factors were placed under the support category

if they assessed constructs that represented aspects related to the facilitators' role and efforts in facilitating students' learning in the collaborative task. We used an item-focused coding approach due to its heterogeneity across disciplines.

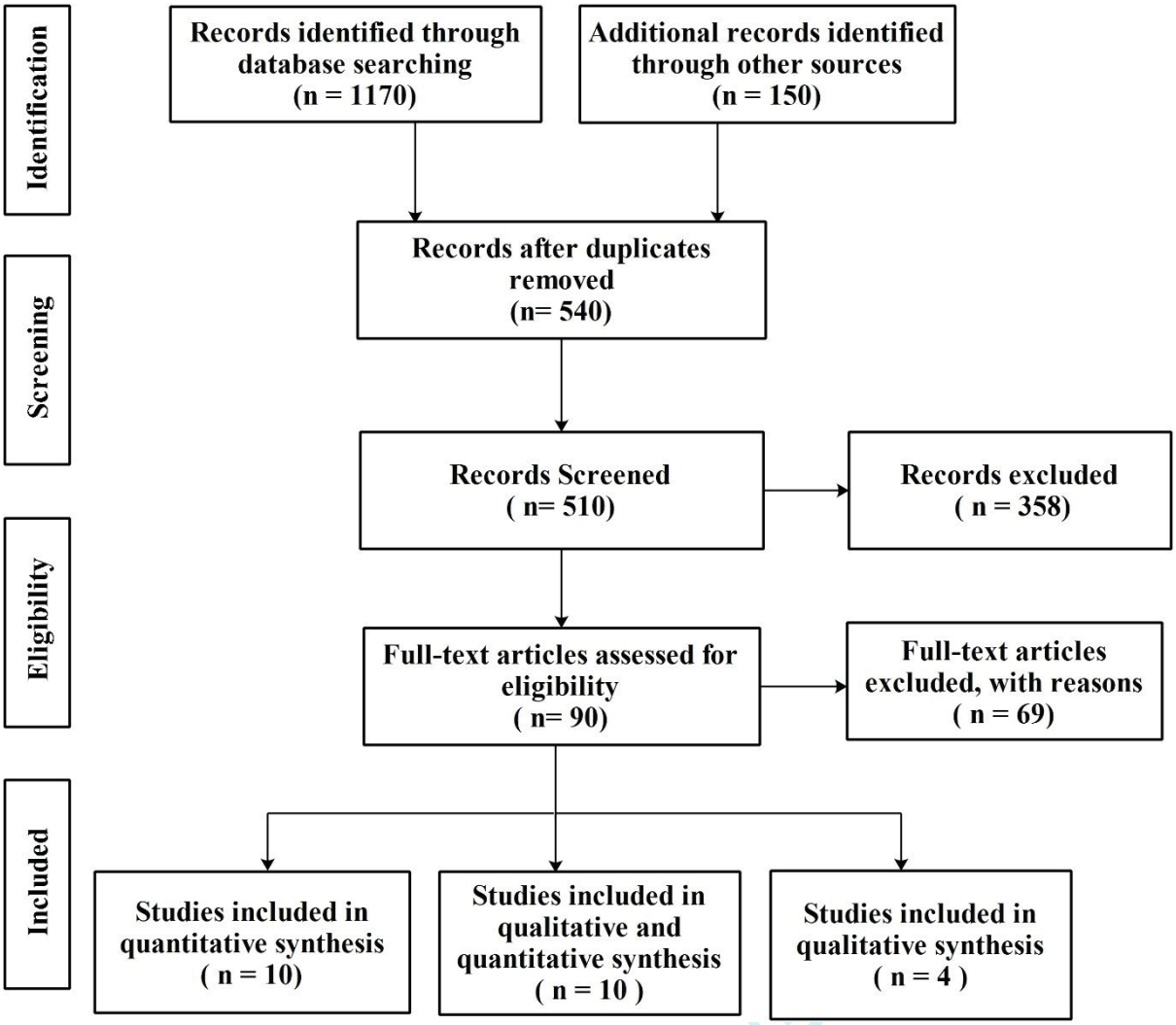

Figure 1: Summary of searching and selection of potential articles

Quality assessment

Two experts (university lecturers with 10-15 years of experience) reviewed the 24 papers (10 quantitative, 4 qualitative, and 10 mixed method, see Figure1) individually. The quality of publications was assessed based on:

1. Appropriateness of research design.
2. Appropriateness of overall method and analysis procedure.

3. Generalizability of research findings to the target population from which the sample was drawn.
4. Relevance of the study's purpose in addressing questions raised in this study.
5. Trustworthiness of study findings in relation to our research focus.

Interrater reliability for the coding of the quality indicators was obtained for the selected studies. Based on the recommendation of Cooper, Heron et al. (2007), the interrater reliability was estimated using an item-by-item method and was calculated by dividing the number of agreements by the total number of agreements plus disagreements divided by 100. The average value for the interrater agreement was 93% among experts.

Table 1: Reviews of previous studies on collaborative knowledge building (N=24)

N	Studies	Purpose	Sample	Factors	Category	Activities
1	Yücel and Usluel (2016)	Examined the effects of students' interaction and participation in a collaborative learning environment on their knowledge building.	145 students	Quantity, quality, and content, and scaffolds	Participation and interaction	Creating, reading, and editing notes
2	Niu and van Aalst (2009)	Examined the effects of students' participation in a collaborative knowledge forum on their knowledge building.	114 students	Participation	Participation and interaction	Creating portfolios, open-ended discussion, reading and editing notes, and writing apprehension test.
3	Lai (2015)	Studied how co-construction of knowledge by postgraduate students in an online learning community and pedagogical practices can potentially influence their knowledge level.	12 students	Teaching strategies	Support-related factors	Discussion forum, one-to-one dialogues, and synergistic discussions.
4	Schellens, Van Keer et al. (2005)	Investigated the effects of assigning discussion roles to students on their levels of knowledge.	286 students	Student characteristics task characteristics; role type	Student-related factors Task-related factors Participation and Interaction	Sharing information, identifying areas of disagreement, negotiating meaning, evaluating and modifying new schemas.
5	De Wever, Van Keer et al. (2010)	Examined the impact of different role assignments on students' level of social knowledge in online discussion groups.	273 students	Role assignment / condition; and role type	Participation and Interaction	Negotiating meaning, evaluating and modifying new schemas.
6	Hew and Cheung (2011)	Identified factors that may influence students' higher-level knowledge building in asynchronous online discussions.	50 students	Group size; duration of the discussion; and facilitation technique	Support-related factors	Face-to-face and asynchronous online discussion.
7	Gutiérrez-Braojos and Salmerón-Pérez (2015)	Explored how students' knowledge building can be facilitated by the use of forum networks.	72 students	Individual commitment; and individual efficacy quality of contributions	Student-related factors Participation and interaction	Sharing resources
8	Cacciamani, Cesareni et al. (2012)	Investigated the influence of different levels of participation, facilitator styles, and metacognitive reflection on students' knowledge building activity.	131 students	Supportive tutoring; and metacognitive reflection. participation level	Support-related factors Participation and interaction	Participate in online discussion.

9	Cesareni, Albanese et al. (2008)	Studied the relationship between metacognitive skills and participation in online knowledge building groups.	399 students	Supportive tutoring; and metacognitive reflection.	Support-related factors	Participate in online discussion.
				participation level	Participation and interaction	
10	Naranjo, Onrubia et al. (2012)	Studied the relationship between participation in an online discussion forum and the cognitive quality of the contributions made by students.	17 students	Student participation (presence and connectivity)	Participation and interaction	Participate in online discussion.
11	Ioannou, Demetriou et al. (2014)	Examined how student facilitation and quality of initial postings may influence collaborative knowledge in online discussions.	34 students	Student facilitation Quality of online postings	Support-related factors Participation and interaction	Sharing/adding posts, negotiating meaning, elaborating, evaluating/testing synthesis, consensus/applying knowledge.
12	Lin, Chang et al. (2017)	Explored the potential of enhancing college students' creative capacity through idea-centered knowledge building activities in a knowledge Forum discussion.	38 students	Creative thinking Quantity and quality of ideas	Student-related factors Participation and interaction	Sharing resources
13	Hong and Chiu (2016)	Investigated the development of students' knowledge building based on the quantity and quality of ideas in the knowledge forum environment.	34 students	Quantity and quality of ideas	Participation and interaction	Notes reading, notes building, and problem-solving.
14	Hong and Lee (2008)	Examined the quality of students' knowledge in a blended collaborative learning environment.	22 students	Task Facilitator discussion	Task-related factors Support-related factors	Participate in asynchronous computer conferences and online discourse.
15	Cesareni and Fujita ((2014)	Examined the effects of role taking on students' participation in a knowledge building activity.	143 students	Role assignment / condition and role type	Participation and interaction	Participate in online discussion, concept mapping, writing and reading.
16	Chen, Resendes et al. (2017)	Investigated temporal patterns that can predict productivity of knowledge building discourse in an online forum.	132 students	Productive threads	Participation and interaction	Creating, reading and editing online notes.
17	Tsai, Chai et al. (2016)	Investigated the relationships between students' perceptions and knowledge building behaviours after the collaborative knowledge task.	177 students	Perceptions	Student-related factors	Reading, adding, and assessing ideas.
18	Cacciamani (2017)	Analysed the patterns of participation and interaction among students in the online environment, implemented with reference to experiential learning and the knowledge building model.	17 students	Social attractiveness and social influence	Participation and interaction	Creating, reading, connecting and editing notes.
19	Spadaro, Sansone et al. (2009)	Investigated the impact of role-taking in a blended learning course in terms of students' participation and perception in acquiring academic skills.	70 students	Role type	Participation and interaction	Participate in online discussion, online writing and reading activities.
20	Sing and Khine (2006)	Examined the pattern of participation among online users in the knowledge building community.	11 students	Participation; social and cognitive	Participation and interaction	Sharing and comparing information, identifying areas of disagreement, and

				Duration of the discussion	Support-related factors	negotiating meaning among group members.
21	Tsai, Chai et al. (2016)	Investigated the relationships between students' conceptions of knowledge building, knowledge building behaviors, and learning outcomes.	48 students	Participation (learning outcomes)	Participation and interaction	Creating, reading, connecting, and editing online notes.
22	Avcı (2019)	Examined the role assignment and scaffolds in promoting students' participation in collaborative knowledge building activities.	77 students	Role assignment and scaffolds	Participation and interaction	Participate in online discussion.
23	Hong, Lin et al. (2019)	Investigated the effects of knowledge building principles on pre-service teachers' reflective capacity.	25 students	Quantity of online interactive, Quality of online feedback	Participation and interaction	Creating, reading, and editing notes
24	Nachowitz (2018)	Examined how the use of Knowledge Forum can help students apply the elements of a progressive knowledge-building discourse.		Scaffolds	Participation and interaction	Creating, reading, linking, and editing notes

RESULTS

Factors affecting students' knowledge building in an online collaborative environment

The results on factors influencing collaborative knowledge building were categorized into interaction and participation (42%), task (20%), student (29%), and support (9%). The influence of these factors on students' knowledge building process is explained in the following sub-sections.

Interaction and participation-related factors

Interaction and participation have been recognized as the most important components for stimulating the learning experience of students in different online collaborative learning settings. The literature revealed the role of these components in engaging students with continuously collaborative sharing and exchange of ideas (Hrastinski 2008). They mediate the structuring of personal opinions and common perspectives of students in the knowledge building community (Scardamalia, Bereiter et al. 1994, Yücel and Usluel 2016). They also provide a reliable and permanent record of previous sessions' experiences for the development of students' understanding of ambiguate tasks (Niu and van Aalst 2009). Since many previous studies considered both interaction and participation to be related to each other (Lipponen, Rahikainen et al. 2003, Sing and Khine 2006, Naranjo, Onrubia et al. 2012, Yücel and Usluel 2016), the realization of participation is difficult without interaction, and vice versa. This study classified the interaction and participation-related factors affecting collaborative knowledge building into seven categories: quantity, quality, role, scaffolds, presence and connectivity, productive threads, and social and cognitive.

Quantity

The quantity of students' interaction and participation in online collaborative knowledge building setting can be characterized as students' active interaction with other members within the same environment. The quantity of participation may provide the means to promote learners' countable learning events during the knowledge building process. This is evident in the work of Yücel and Usluel (2016) who examined the effect of quantity of students' interaction and participation on their knowledge building, as indicated by measuring the frequency of notes creation, reading, and build-on. They found that engaging students in these activities could help increase their participation level and interaction with other members. In addition, many previous studies stated that participation quantity in a knowledge building context can be established by involving students in analytic toolkit indices such as notes creation and revision (Niu and van Aalst (2009); Sing and Khine (2006); Tsai, Chai et al. (2016)). These means of participation are believed to provide the antecedents necessary for promoting individuals' ability to effectively interact with others in terms of establishing relevant cooperative goal structures within groups. Furthermore, Cacciamani, Cesareni et al. (2012) and Cesareni, Albanese et al. (2008) examined how individuals' participation levels might affect online course discussions. They found that students' level of participation can be increased with the increase of note creation. Previous studies, such as Lin, Chang et al. (2017) and Hong and Chiu (2016), found that quantity of ideas, in terms of workability and relevance, are effective in enhancing students' online collaborative and inquiry performance during the knowledge building process. Based on these, the quantity of participation and interaction within the online collaborative learning environment can be promoted by increasing the quantity of note-taking, reading, and revision.

Quality

The quality of online collaborative learning depends on the quality of interaction. When the participation in online collaborative learning environments occurs in a quality manner, a successful knowledge building process and learning process can occur as well. Most studies on online collaborative knowledge building, such as Yücel and Usluel (2016), used a rubric to assess the role of interaction and participation quality in developing knowledge building skills by assessing the value of contributions (messages) made during the discussion, the relevance of these contributions to the topic under discussion, the continuity of the contribution received from individual students, and the direction of relations between discussion messages. The higher the quality of participation and interaction is, the more progress will take place in online discussions and higher the construction of knowledge will be (Ioannou, Demetriou et al. (2014). The quality of students' participation in the collaborative knowledge construction process can be achieved by structuring online postings in terms of content and monitoring/modelling high-quality postings in the early stages of the discussion. Some studies (e.g., (Näykki, Järvenoja et al. 2017, McDonough, De Vleeschauwer et al. 2018) have shown that students' perceptions regarding the course structure may positively influence their overall interaction and participation with the course. This led us to assume that providing a good structure of learning contents may increase online collaborative dialogue and interaction among students. Furthermore, Lin, Chang et al. (2017) and Hong and Chiu (2016) have investigated how students' collaboration towards establishing innovative ideas can promote their perception of ideas quality during the knowledge building process. They found that an increase in the quality of ideas (in terms of the workability and relevance of ideas) will help in improving the quality of interaction and participation and will create the atmosphere for students to deepen their knowledge about the topic under discussion. In addition, Tsai, Chai et al. (2016) found that aspects related to

accuracy, diversity, and organization of content can be associated with the quality of individual's participation and interaction.

Role

The role an individual plays in the collaborative group has been found to influence the participation and interaction level of students (Cesareni and Fujita , Schellens, Van Keer et al. 2005, Spadaro, Sansone et al. 2009, De Wever, Van Keer et al. 2010, Lai 2015). Previous studies reported that the role of individual students may contribute to the overall quality of discussion by helping others to clarify confusions and to locate major debates about the topic under discussion. According to De Wever, Van Keer et al. (2010), assigning roles to students can be an effective indicator for increasing the level of social knowledge construction in online discussions. In addition, the role undertaken by the students, both as forum moderator and discussant, may potentially affect the knowledge building process (Schellens, Van Keer et al. 2005). Students' role in the discussion can be assigned in the form of tutor, editor, starter, summarizer, moderator, theoretician, source searcher, synthesizer, and mapper, which were found to provide a crucial structuring tool for improving the level of participation in the online knowledge building practices (Cesareni and Fujita , Schellens, Van Keer et al. 2005, Spadaro, Sansone et al. 2009, De Wever, Van Keer et al. 2010).

Scaffolds

In the study of Law, Yuen et al. (2011), scaffolds have been defined as one type of knowledge support that students can use to form and discuss their own opinions in the knowledge building activities. Hong and Lee (2008) has shown that scaffolding is important to increase knowledge among students because it enables them to easily convey their opinions, ask for an opinion or encourage participation, sustain knowledge telling, and

facilitate self-evaluation. The aim of using scaffolds is to help students develop and express their own opinions on common tasks (Lin, Chang et al. 2017). Thus, providing the necessary scaffolds in support of knowledge building can help students establish communication and interact with their other group members (Lock and Duggleby 2017, Lin and Chan 2018).

Presence and connectivity

In online collaborative learning, the strategies for sustaining the sense of connectivity and presence have been found to play a critical part in students' participation and interaction (Nam 2017, Zheng 2017). Naranjo, Onrubia et al. (2012) carried out a structural analysis of students' participation using indicators related to students' presence and interaction during the online discussion. They asserted that both presence and connectivity throughout the online discussion in the knowledge building process should be promoted due to their role in maintaining high-quality knowledge contributions. According to Gracia-Moreno, Cerisier et al. (2017), presence seems to be necessary to maintain continuous access to the discussion forum, as well as ensuring that new contributions are continuously made at different times throughout the discussion sessions. In contrast, connectivity is another element important for encouraging students not only to contribute new ideas and to initiate active discussions but also to respond specifically to the contributions made by others. This include making direct interaction with other numbers, thus facilitating knowledge building in teams (Poquet, Kovanović et al. 2018).

Productive threads

Several prior studies have documented diverse epistemic moves for promoting knowledge building discourse, including formulating hypotheses, posing questions, and designing experiments to investigate hypotheses (Scardamalia 2002, Zhang, Scardamalia et

al. 2007, Chen, Resendes et al. 2017). Chen, Resendes et al. (2017) investigated the sequential patterns that can predict productivity threads of knowledge building discourse in the online forum. They found that discussion threads which have more transitions between questioning, theorizing, working with information, and obtained information to be more productive in the discourse of knowledge building. In addition, the use of threads in online collaborative learning has been addressed by Zhang, Scardamalia et al. (2007) to foster students' participation and interaction in the knowledge building practices. They found that responding to questioning and theorizing by merely giving opinions are significant factors to achieve progress in knowledge building. The results identified further links between patterns of productive threads including the effective use of evidence represented in sequences of events, sustained theorizing, and repeated attempts to problematize suggested theories. These merits could be connected with the method of creating knowledge of discourse related to building annotations, constructive use of information, and deeper investigation (Lin and Chan 2018).

Social and cognitive

The importance of the social context has received increasing attention in online collaborative learning research and has been examined both quantitatively and qualitatively. Cacciamani (2017) analyzed the patterns of interaction and participation in terms of social attractiveness and social influence among participants in the online environment. He found that students were reluctant to participate in the online collaborative activity because they lacked a sense of communication, which, as a result, affected their overall participation. In addition, participants were interested in responding to certain contributions delivered by other members which they perceived to be relevant to their contributions. This experience may potentially contribute to the participants' intent to share and build knowledge (Zhang, Liu et

al. 2017, Habibi, Mukinin et al. 2018). Sing and Khine (2006) examined the pattern of online interaction discourse analysis among students in an online collaborative learning task. They identified the role of social and cognitive factors in stimulating students' online interaction. It was argued that participants who engaged in a socially cohesive knowledge building community may actively participate in solving issues related to the discussion. In addition, the discipline of students where critical and creative discourse are articulated could potentially contribute to the knowledge building discourse instantly, especially when basic social cohesiveness is established (Cleveland and Block 2017, Hurst, Azevedo et al. 2018). Thus, cultural and social dimensions must be taken into consideration in order to ensure an effective knowledge building practice.

Based on these, we found seven sub-factors (see Figure 2) influencing students' participation and interaction in collaborative knowledge building, namely: quantity, quality, role, scaffolds, presence and connectivity, productive threads, social and cognitive factors.

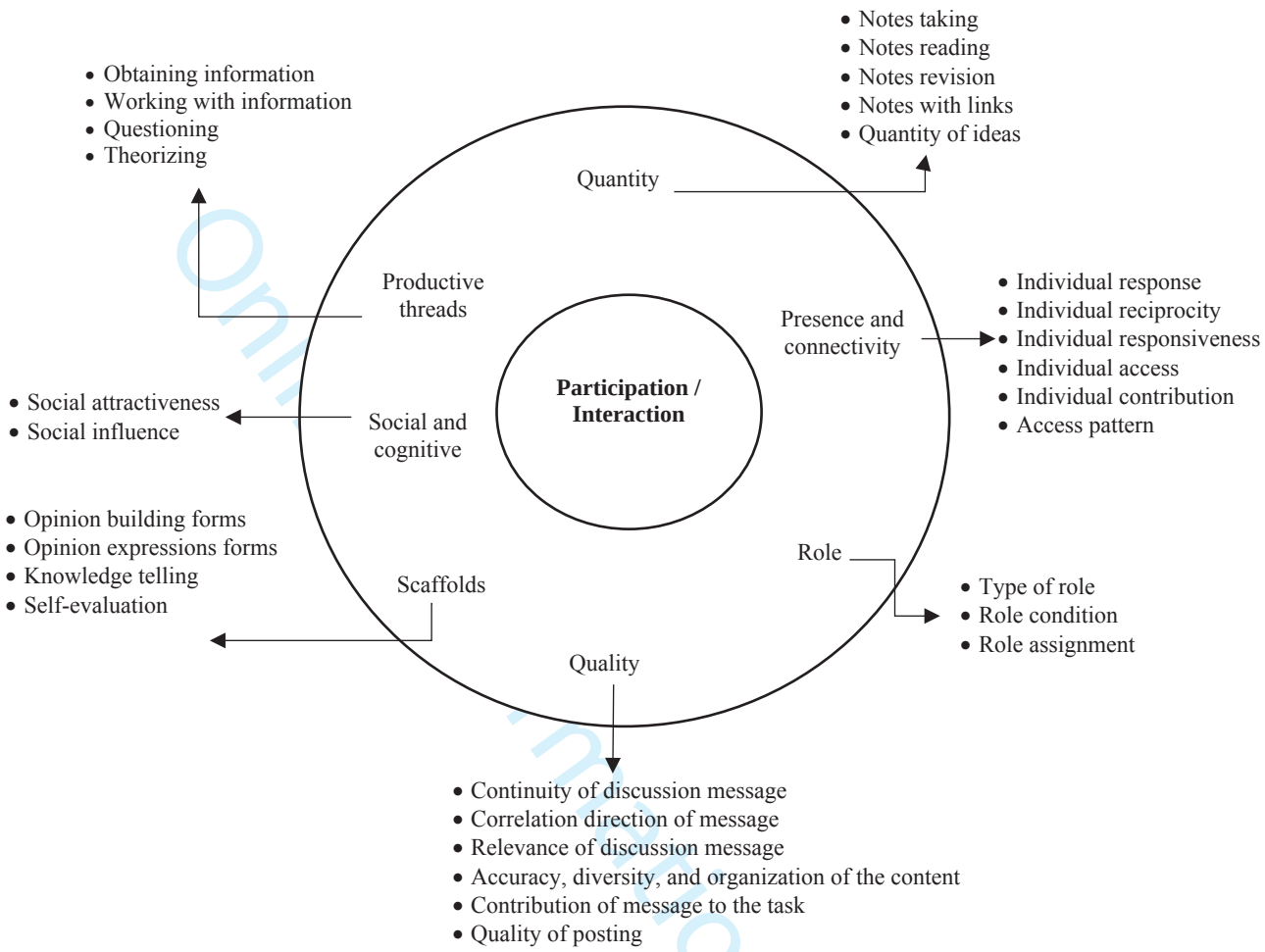

Figure 2: An illustration of factors related to interaction and participation

Task-related factors

Task characteristics are an important dimension of online collaborative learning and have been found to be an essential predictor of students' knowledge building processes in various contexts (Nah, Mennecke et al. 2009). They can be examined through the complexity, coordination, and design of the learning tasks which are delivered during the collaboration activity. Schellens, Van Keer et al. (2005) analyzed the influence of task complexity on students' levels of knowledge. The results revealed that a large portion of the overall variance in students' levels of knowledge building was due to differences among the various tasks and discussion themes. Others like Chae, Seo et al. (2015) found that students performing

complex tasks through intense collaboration can potentially experience different levels of knowledge building. Since the main aim of collaboration-based activities is to deal with complex tasks, Hong and Lee (2008) found a relationship between knowledge building and individuals' behaviors towards the task. Based on these, it can be said that the amount of knowledge gained in the collaborative task depends largely on how the students perceive the given information to solve a learning problem (Shiga, Joho et al. 2017, von Davier, Hao et al. 2017). In addition, the literature showed that a high degree of task complexity may be due to elements of ambiguity and difficulties which require individuals to acquire new knowledge at a time (Akgün, Byrne et al. 2005). This was also supported by Schellens, Van Keer et al. (2005) who argued that the more complex the task, the more information is needed for an individual to solve the learning problem. As such, students of the one group need to spend more time gathering or building knowledge essential for the creation of novel ideas. Lai (2015) argued that the design of a learning task can influence students' cognitive development during the online collaborative knowledge building activities. This includes the influence of task structure on students' ability to complete work using knowledge forum tools and to engage in effective online dialogue discussion (Ludvigsen and Arnseth 2017). Other scholars like Yücel and Usluel (2016) used the code scheme to examine how certain task-related factors would contribute to the overall knowledge building of students in the collaborative group. They addressed the role of task coordination as an important factor directing students' participation in a knowledge building context. A well-designed learning task is believed to increase students' motivation to complete their learning, leading to greater knowledge building and sharing outcomes (Pee and Min 2017, Wang, Cheng et al. 2017, Tao and Zhang 2018). Based on these observations, this study proposes that aspects related to the design, complexity, and coordination form the main antecedents of the task dimension in the collaborative knowledge building space.

Student-related factors

In this study, student-related factors refer to individuals' characteristics that affect their academic performance, attitude, perception, behaviors, intellectual skills, and experiences in the collaborative learning environment. Several studies have revealed that the CSCL environment could be more efficient when the personal characteristics of learners are considered in its design. For example, the study of Schellens, Van Keer et al. (2005) investigated the effect of student characteristics such as attitude toward the knowledge building environment, and the amount of messages contributed to the discussions on the level of knowledge. They found that students' attitudes toward the learning environment had a significant positive effect on their mean level of knowledge building per discussion theme. Attitude towards the discussion has also been highlighted by other previous studies (e.g., (Serrat 2017, Yerdelen-Damar, Boz et al. 2017, Formosa, Morrison et al. 2018) to be mutually associated with students' knowledge building behaviors in the CSCL environments. Gutiérrez-Braojos and Salmerón-Pérez (2015) analyzed and discussed a theoretical model 'collective cognitive responsibility' and its effect on students learning in a virtual knowledge building community. They examined the knowledge building activity in which students are engaged based on their commitment to collective cognitive responsibility, the cognitive complexity of their contributions, individual members' efficacy in evaluating other contributions, and individual students' impact. Other scholars like Lee, Lajoie et al. (2017) asserted the importance of collective cognitive responsibility as a means for sustaining knowledge transformation in inquiry communities. They stated that promoting individuals' competencies in the online collaborative environment should be encouraged and managed, particularly to sustain collective cognitive responsibility. This is believed to positively contribute to the symmetry of students' knowledge building (Gutiérrez-Braojos and Salmerón-Pérez 2015, Cress and Kimmerle 2017).

In contrast, many studies have investigated the influential impact of students' perceptions of the collaborative learning activities on the development of their knowledge. For example, the study of Tsai, Chai et al. (2016) examined the relationships between individuals' perceptions and knowledge building behaviors in the collaborative knowledge building activities. They found that when students were provided with few clues and pictures or videos, they did not always perceive the environment as increasing their knowledge level. This is because students may find it difficult to gather evidence to confirm their perspectives (Muhonen, Rasku-Puttonen et al. 2017, Furtak, Bakeman et al. 2018), thus negatively influencing their perceptions towards the feasibility of an environment for the facilitation of the knowledge building process. Moreover, Lin, Chang et al. (2017) explored how knowledge building could support the generation of creative ideas among students in order to foster their productivity. They found that aspects related to students' thinking skills significantly contributed to their knowledge building by facilitating creativity and work more collaboratively and autonomously with ideas. It can be said, therefore, that aspects related to students' attitude, competency, perception, efficacy, and thinking skills are the main elements contributing to students' online collaborative knowledge building.

Support

Facilitation techniques

The literature showed that the utilized facilitation techniques may play a key factor in shaping students' knowledge building in an online collaborative learning space. For instance, Hew and Cheung (2011) studied the influence of four types of facilitation techniques (providing comments and opinions, showing appreciation of students' inputs in real time, continuous encouragement, and summarizing key points of the discussions) on students' knowledge building. Their findings showed that these four types of facilitation techniques

have succeeded in increasing the level of students' knowledge. When students are allowed to exchange opinions, they are more likely to benefit from the experiences of others, thus making the content relevant and creating testable theories (Sun and Gao 2017). Furthermore, when the contributions of students are encouraged and instructor comments are answered appropriately, students are likely to form unique views for debate thus increasing their participation further and enhancing the knowledge building experience accordingly (Tegos and Demetriadis 2017).

On the other hand, the role of individual students as facilitators of the discussion in the collaborative learning environment has been investigated in many previous studies (e.g., (Hew and Cheung 2011, Ioannou, Demetriou et al. 2014). Student facilitators were found to increase the level of thinking and the sense of connectedness in the knowledge building group. However, feedback distributed across the learning activities should be sustained and provided by different individual members at different times (Getto 2013). The student as a facilitator is more closely aligned with the discussion scope and sequence which helps to increase group members' positive perception of being connected to others (Hew and Cheung 2011, Ioannou, Demetriou et al. 2014). This may potentially help in providing an open atmosphere and deepen relationships between the group members in a way that enables students to easily share and build their knowledge. In contrast, other studies noted that student facilitation increases the activity of the online discussion. For instance, Ioannou, Demetriou et al. (2014) examined how student facilitation may influence collaborative knowledge in online discussions. They found that the frequency of messages exchanged among students tend to provide an indication of their critical thinking performance essential for developing knowledge.

Facilitator strategies

Designing the environment is not enough for successful online collaborative learning, it also requires effective facilitation strategies. Previous studies on the cognitive aspects of online learning communities have emphasized the role of various teaching strategies to support the knowledge building process. For instance, Lai (2015) examined the effect of various pedagogical practices in an online learning community and found evidence of their potential in advancing the knowledge building process among students. The findings showed that teaching strategies and the flow of the discussion were the main factors influencing the extent and quality of knowledge constructed among the collaborative group members. In addition, they confirmed the importance of agency and leadership in moderating students' progress in online discussions. Such practices are believed to provide a social constructivist and social cultural approach, allowing the construction of knowledge in a community of practice (Cacciamani 2017).

Hong and Lee (2008) showed the importance of using facilitating strategies such as progressive questions, monitoring, and explaining concepts in sustaining students' knowledge in the collaborative space. They discovered that facilitators of the discussion who encouraged other members to think critically and to reflect upon their own understanding were most successful in guiding the group to a deeper level of understanding. This may be because certain members of the group, who are unable to understand the topic, are likely to pay less attention to the activity. Other aspects related to the influence of facilitator styles and meta-cognitive reflection on the students' knowledge building activity in online collaborative environment were also reported in previous studies (Cesareni, Albanese et al. 2008, Cacciamani, Cesareni et al. 2012). Results from these studies showed that a supportive tutorship style and opportunities for meta-cognitive reflection on their own participation strategies were related to the students' advanced epistemic agency in the collaborative

knowledge building task. These factors were found to be useful in fostering online participation and the cognitive presence of the students. Moreover, Cacciamani, Cesareni et al. (2012) reported that students' meta-cognitive reflection space aided their participation by enabling them to develop skills that enhanced their classroom experiences and the creation of new knowledge. Reflection has also been shown to aid the development of students' meta-cognitive skills by making them aware of their own knowledge and ability to understand the topic under discussion (Feucht, Lunn Brownlee et al. 2017, Alexander 2018).

The presence of the tutor and his/her mode of interaction with the students are factors that make the difference in improving individual meta-cognitive skills in the community of knowledge building (Song, Kim et al. 2018). According to Sohal, Perry et al. (1998), the facilitator's style could be described as encouraging, positive, affable and organized. Hence, the facilitator's style can lead to a shared epistemic agency that, accordingly, can expand the knowledge of a specific concept. For example, the facilitator can provide the style of interaction required to facilitate cooperation with and among the students. The tutor could also facilitate change in the student's working with knowledge model by using insightful questions, offers new cues, and suppling materials upon which to be commented (Hong and Lee 2008). This style could help students understand and formulate relevant hypotheses in online discussions which later can be used to further express their own evaluations of others' ideas.

Challenges highlighted in the literature on collaborative learning reflect concerns about how group size and duration of the online discussion may contribute to the overall knowledge building process (Ouyang and Scharber 2017). This suggests that the facilitator of collaborative discussion needs to become familiar with different strategies to manage discussions in both large and small online classes (Oh, Huang et al. 2018). During the knowledge building process, group size has been found to limit students' share of

responsibility, thus discouraging social loafing among the group members (Sing and Khine 2006, Hew and Cheung 2011).

Based on these observations, we categorized the support dimension into facilitation techniques and facilitator strategies as shown in Figure 3.

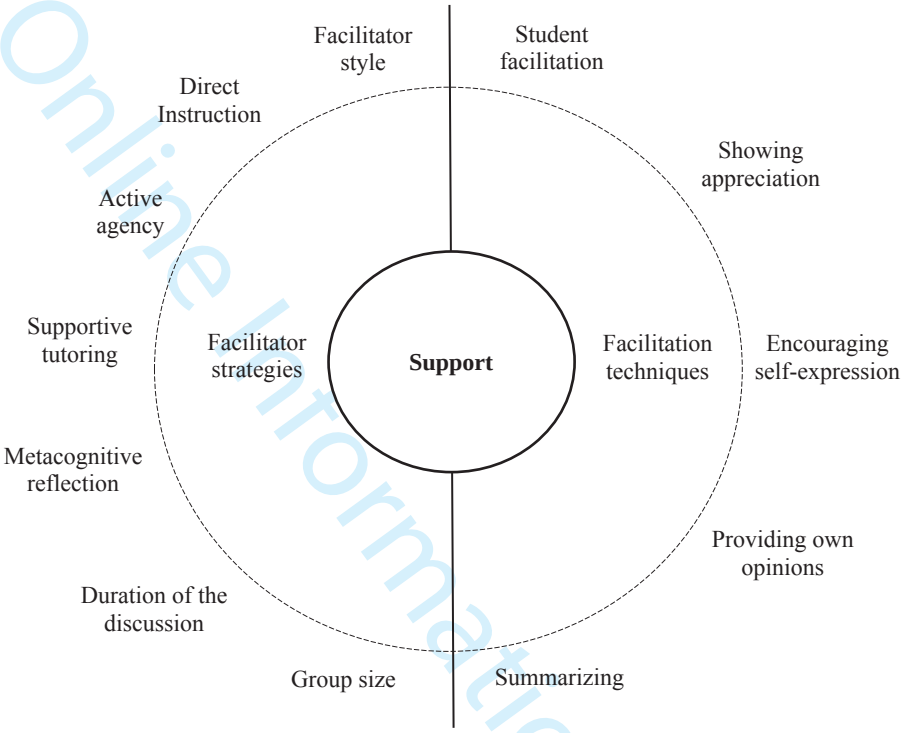

Figure 3: An illustration of the support-related factors

The association between factors of knowledge building and online collaborative learning activities

In the knowledge-building community, a student is allowed to create, criticize and develop knowledge in a constructivist manner. During this, there are several activities that students should engage in. Activities such as brainstorming ideas, identifying problems, researching for solutions and evidence, debating and discussing with peers have a clear goal of co-creating new perspectives and advancing knowledge beyond the limit of an individual. Our review of the literature showed that certain collaborative learning activities may vary in their effectiveness in knowledge building. From Table 1, it can be concluded that to examine

the effects of certain factors (e.g., interaction and participation, students' characteristics, support, and task-related factors) in a collaborative learning environment on the knowledge building process, students need to engage in certain activities that can result in active learning. For example, Yücel and Usluel (2016) examined the effects of scaffolding, quantity, and quality of interaction and participation on students' knowledge building by collaboratively create, read, and edit online notes. In contrast, Lin, Chang et al. (2017) explored the potential of enhancing college students' creative capacity through sharing resources and idea-centred knowledge-building activities in a knowledge forum discussion.

Table 2 shows the association between the above discussed factors for each dimension of collaborative knowledge building and the learning activities the students engage in based on the studies in Table 1.

From Table 2, it can be seen that collaborative learning activities such as adding notes/posts (contributions), editing notes (revisions), reading notes, sharing information, writing comprehension tests, identifying areas of disagreement, and negotiating meaning to be useful in promoting students' interaction and participation in the discussion group. Adding notes or new posts to address certain concerns can help reduce ambiguity and direct students towards further participation. In addition, the interaction resulting from editing these notes by other members is conveyed to facilitate communication between students. Information sharing, self-evaluation, and problem solving, on the other hand, were found to promote students' thinking skills, efficacy, and competency in the collaborative knowledge building process. These activities are believed to provide better opportunities for students to engage in mutual learning and make the practice of peer assessment more efficient among members. Our review of the literature showed that instructors or facilitators must consider certain design aspects when engaging a group of students in online collaborative knowledge building. Task-related factors such as complexity, coordination, and design must be

considered in the learning activities that reinforce real-time elaboration, concept mapping, and identifying areas of disagreement. This is because when students perceive the task to be complex or feel they do not have the ability to solve it, they may not actively participate in the discussion sessions. Activities that have been found to benefit from additional support (facilitation techniques and facilitator strategies) were related to adding notes/posts, real-time elaboration, problem solving, identifying areas of disagreement, and negotiate meanings. Finally, understanding the association between certain factors and learning activities can help extend the current research on knowledge building by providing the necessary behavioral and cognitive interventions to the discussion process, thus enhancing students' collaborative knowledge building in online environment.

Table 2 Associations between factors of knowledge building and online collaborative learning activities

Dimensions	Factors	Activities											
		Adding notes/posts	Reading notes	Sharing information/ resources	Editing notes	Realtime elaboration	Self-evaluation	Synthesis	Writing apprehension test	Problem-solving	Concept mapping	Identifying areas of disagreement	Negotiate meanings
Interaction and participation	Quantity	✓	✓	✓	✓				✓	✓		✓	✓
	Quality	✓	✓	✓	✓			✓	✓	✓		✓	✓
	Scaffolds	✓	✓	✓	✓	✓	✓		✓			✓	✓
	Presence & connectivity	✓	✓	✓	✓				✓			✓	✓
	Productive threads	✓	✓	✓	✓				✓			✓	✓
	Social	✓	✓	✓	✓				✓			✓	✓
	Role	✓	✓	✓	✓		✓		✓		✓	✓	✓
Student	Attitude			✓			✓					✓	✓
	Thinking skills			✓						✓			
	Competency			✓			✓			✓			
	Efficacy			✓			✓			✓			
	Perceptions		✓					✓					✓
Task	Complexity			✓		✓	✓					✓	✓
	Coordination					✓					✓	✓	
	Design										✓		
Facilitator Strategies	Facilitator style	✓	✓						✓				
	Direct Instruction									✓	✓	✓	✓
	Active agency					✓	✓						
	Supportive tutoring							✓		✓			✓
	Metacognitive reflection	✓				✓					✓		
	Duration of the discussion			✓								✓	✓
	Group size									✓		✓	✓
Facilitation Techniques	Student facilitation	✓	✓	✓									
	Showing appreciation					✓			✓			✓	
	Encouraging self-expression	✓				✓				✓	✓	✓	

	Providing own opinions		✓					✓					✓
	Summarizing	✓					✓		✓	✓			✓

FINAL REMARKS

A summary of the key dimensions and factors affecting students' knowledge building in an online collaborative learning environment is presented in Figure 4.

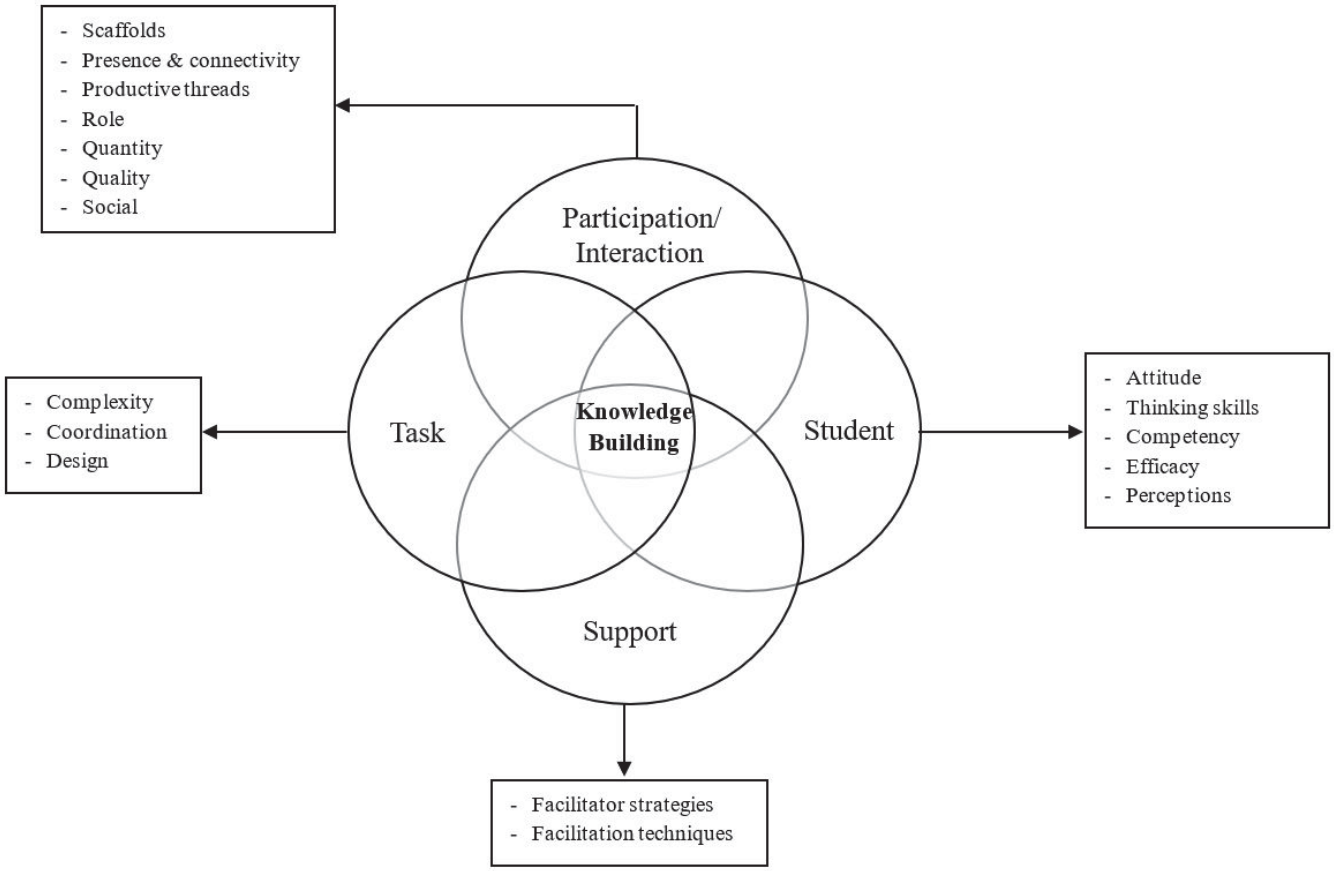

Figure 4: A conceptualization of factors affecting students' collaborative knowledge building in an online environment

Our aim here was to conceptualize the factors that will help institutions of higher education to provide the conditions for students to effectively participate in online collaborative knowledge building. Factors that can facilitate students' participation and interaction such as scaffolds, presence and connectivity, etc. were found to be very effective in building individuals' knowledge in an online collaborative space. This is due to the fact that they provide a stimulating experience by allowing students to add and elaborate on their own views with others. We found that a higher level of participation in the online collaborative learning can be facilitated by increasing the quantity of interaction through the

engagement of students in notes or post creation, notes reading, sharing resources, identifying areas of disagreement and negotiating meanings. The quality of participation and interaction also was found to depend very much on the continuity, correlation, relevance, and contribution of discussion messages to the task. Precisely, the quality of online posts and notes can play an important role in determining the quality of interaction and participation among students in the knowledge building process, as supported by Ioannou, Demetriou et al. (2014). The process of scaffolding in the form of teachers' supports is essential for the epistemic agency of students by supporting and leading students in expressing and building their opinions in a knowledge building process (Xu, Wang et al. 2018). Both presence and connectivity were found to promote knowledge building as they foster both continuous access to the online forum and the making of contributions at different times throughout the discussion sessions. They also helps students to establish direct communication channels between students that allow a thorough analysis and discussion of each person's contribution in the knowledge building process (Naranjo, Onrubia et al. 2012). This study found that participants' social factors of mutual interaction and belonging to a group could probably contribute to the participants' intent to build and share knowledge. Thus, these social factors in terms of social attractiveness and social influence may directly influence an individual's knowledge building intentions. The type of role assigned to students can provide an important structuring factor towards own knowledge development. It can be also said that facilitating students' participation in productive inquiry threads may offer significantly more transitions through questioning, theorizing, obtaining information, and working with information to achieve knowledge progress in an online collaboration learning.

Student characteristics in terms of attitude, thinking skills, competency, perception, and efficacy toward the online collaborative learning environment were found to play a significant role in increasing students' conceptions and approaches towards building

knowledge. A clear task structure is required to foster cognitive processing and academic performance in the online collaborative knowledge building. In addition, task complexity and coordination can be highly associated with students' behaviors towards the online discussion group. This study assumes that engaging students in learning tasks such as managing ideas, sharing resources, explaining or elaborating, and seeking feedback will potentially enable students to take responsibility and increase their symmetry, thus advancing their knowledge building.

We found that facilitator strategies such as direct instruction, active agency, duration of discussion, and group size design can contribute to students' performance in the knowledge building process. Furthermore, we found that facilitator style and providing ample opportunities for meta-cognitive reflection on the students' own participation were the most conducive for fostering epistemic agency by using functions prepared in online knowledge forum. Introducing facilitation techniques such as summarization, providing own opinions, encouraging self-expression, showing appreciation, and student facilitation was found to help students engage more in knowledge building activities by increasing students' responsibility toward the discussion topic, thus facilitate knowledge building among others.

IMPLICATIONS FOR POLICY MAKERS

This study contributes to the existing literature on knowledge building and suggests theoretical and practical implications for different streams of research in the future. For example,

1. Knowledge-building pedagogy can encourage students to engage in a more authentic learning experience through generating and continually improving their own ideas and thoughts in order to address authentic and complex academic tasks.

2. Investigating students' characteristics in CSCL environments may raise new questions and shed light on how theories examining online learning as socio-metacognitive and epistemological processes can be advanced.
3. Engaging students in knowledge building practice is essential for promoting more reflective discourse among the group members. Certain factors related to the quantity, quality, scaffolds, presence and connectivity, productive threads, social, and role of the tutor can be embedded to promote students' participation and interaction in the collaborative knowledge building process. Effective learning activities such as identifying areas of disagreement, sharing information/ resources, and negotiating meanings can be helpful for knowledge building in a problem-based learning group.
4. Providing students of the collaborative group with the means to effectively generate and continuously improve their ideas and thoughts in online collaborative group settings can significantly contribute to the knowledge building process.
5. The association between certain collaborative learning activities and knowledge building factors may help identify ways to design an effective learning environment for promoting literacy development and knowledge building, thus addressing the compelling needs of 21st century education.
6. This study encourages educators to implement collaborative knowledge building pedagogies that rely on the design of a flexible curriculum in order to allow emergent understanding to occur among the group members. Doing so would result in a highly motivating learning process, which can result in changing the classroom dynamics and promoting collaboration and participation among students.
7. Providing continuous support to the collaborative discussion will significantly empower current educational practices by providing sufficient incentives and supports to help students perceive the value of the learning process, thus positively influencing

their behavioral intentions. Meanwhile, educational policy makers are encouraged to stimulate online students-to-instructor interaction in a university context as well as ensuring progressive monitoring of the online activities among group members in the collaborative task. These means are believed to influence the way students respond to others' contributions and behave as an active member.

8. The administration should also be encouraged to emphatically stipulate that knowledge building is vital to the sustainability of the online knowledge community. Students in the discussion sessions should be introduced to various facilitation techniques and strategies to ensure the sustainability of the online knowledge community. Administration must ensure that students are equipped with the learning resources and tools (e.g., models for the different types of contribution, specific discussion roles, discursive scaffolding) in order for them to formulate their contributions appropriately.

Finally, it is hoped that these remarks can help decision makers of higher education in both developing and developed countries to take the necessary steps/interventions in order to promote online collaborative knowledge building. It may also help educational policy makers to understand the particulars of collaborative knowledge building practices, so to increase organizational overall effectiveness and performance.

CONCLUSIONS

Given the rapid growth of online learning in the last decade, it became essential to understand how students, within online collaborative learning environments, can build their knowledge in order to achieve academic success. This review revealed that improvements in students' knowledge building were related to their level of participation and interaction in collaborative learning activities. In addition, it was found that the design and complexity of the collaborative knowledge building environment can potentially improve the overall

collaborative learning process among the group members. When students work in a complex context, they might have more chance to experience deep and meaningful learning with their classmates. During the collaborative learning session, learning support should be provided to promote and stimulate knowledge building. This may also include providing the students with guidelines to participate in the knowledge building process. It is, therefore, advised that the online facilitator or moderator should consider providing adaptive support towards collaborative problem-solving for discussion in an ill-defined domain. The results of this study can be used to improve the structure of the learning activity and teaching process, thus increasing learning and directing the design of online collaborative learning environments.

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