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Distributed Cognition and Its Antecedents in the Context of Computer-Supported Collaborative Learning (CSCL)

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Abstract

Offering great flexibility, information and communication technologies (ICTs) facilitate immediate communication and interaction in either hybrid instruction or online training. Computer-supported collaborative learning (CSCL), mediated by ICTs, have come a long way to be embedded in learning management systems (LMSs). In the context of CSCL, groups of participants are involved to collaborate or interact within the group or between the groups. Of interest, this study proposes a conceptual model integrating Biggs' Presage, Process, Product (3P) model and Front-end Analysis (FEA) to explore determinants of distributed cognition in CSCL. This study affirms that (1) the presage factors (i.e., learner attributes, instructional attributes, contextual attributes have an influence on collaborative practice (CP); (2) the process factor, collaborative practice (CP), has an influence on distributed cognition (Dcog); and (3) participation is a mediator on learner attributes to collaborative practices. The finding lends support to the empirical study by conducting the Delphi technique for qualitative method and/or a large-scale survey for quantitative study. The findings are discussed and further studies are suggested.

Keywords: computer-supported collaborative learning (CSCL), distributed cognition, presage, process, product (3P) model, collaborative practices

1. Introduction

Information and communication technologies (ICTs) afford distributed interaction and collaboration, and facilitates open, constructivist learning environment. Importance of ICTs in fostering interaction with learning environment has its philosophical origins in antiquity (Moore, 2010). Enhanced by ICTs, open learning environments provide a less hierarchical context for learning and instruction, which in turns to better meet learning needs of individuals who could not approach newly-learned information systematically (Mupinga, Nora, & Yaw, 2006). To justify investment in educational ICTs, four commonly accepted rationales are justified: (1) support for economic growth, (2) promotion of social development, (3) advancement of educational reform, and (4) support for educational management (Herrington & Oliver, 1995). As the evolving trend of ICT integration with learning settings, instructors are expected to offer online courses, or to blend the face-to-face teaching practices with ICT-enhanced activities (Asterhan & Schwarz, 2010). To enhance effectiveness of teaching and learning, the interactive approach underlines that the quality of the learning outcome is determined by how learners construct knowledge and how they approach learning tasks (Biggs, 1989). Collaborative learning occurs while learning tasks are assigned to groups. The group members would need to exchange ideas and information to accomplish the tasks, and the members are subjective to be accountable. To be competent in professional education, and professional practices subsequently, Freeth and Reeves (2004) posited that collaborative practice is an important core.

Computer-supported collaborative learning (CSCL) is now commonly applied in various formats when delivering instruction. CSCL environments support instructors and learners an opportunity a shift of their traditional roles in classroom settings assuming that learners prefer knowledge building communities in which they have more control over their learning process (Strijbos & Weinberger, 2010). Stahl and Hesse (2010) suggest that the intent of CSCL strives to incorporate contributions and perspectives from different disciplines

and best practices. The context of CSCL involves groups of participants to collaborate or interact within the group, across the groups, or facilitators. The group size varies from small group of 3–6 members to large group of 7 or more (Forsyth, 1999). To achieve effective collaboration, Zeegers (2002) considered that group learners, particularly for the small group size, should make their learning visible to each other in their discourse. Yet, a challenge posed by CSCL is to stimulate the development of communities of learners (Koschmann, Hall, & Miyake, 2002).

From their meta-analysis, Gress, Fior, Hadwin, and Winne (2010) worked on an extensive literature on the review of articles related to CSCL from January 1999 to September 2006 in the selected databases of academic index. Limiting to empirical research of qualitative and quantitative design, they adopted the search terms of computer, collaboration, learning, and their combination. Among the 186 articles considered as representation of the field, they found 340 measures or methods of collaborative constructs, and 33% of those were self-report questionnaires and 19% were products of collaboration assessing individual differences in light of learning and knowledge construction. More, the quantity of measures/methods used to assess discussion and dialogues were approximately equivalent at 12%, followed by interview data (10%), observations (9%), and then prediction and/or feedback (5%). They reported a number of key findings. First, the majority is self-report, and their empirical data are collected after collaborative activities were administered. Very few studies collected baseline information before collaborative activities were implemented. Second, the findings and recommendations in the field are mostly from the post-only research design. Third, data collection is overly dependent on text-based measures to examine instructional and learning process involved in CSCL. Their research findings summarize learning processes and outcomes of learners, provide opportunities for learners to monitor, evaluate, and adapt learning during independent and collaborative activities.

Recent studies in CSCL have indicated the findings that learners contribute differently to discourse (Bullen, 1998; Calvani, Fini, Molino, & Ranieri, 2010; Messick, 1989; Rienties, Tempelaar, Van den Bossche, Gijselaers, & Segers, 2009). Individuals approach their learning with an aid of different ICTs tools, styles, and strategies (Barker, 2008; Biasutti, 2011; Zhu, Valcke, & Schellens, 2010), computer self-efficacy (CSE), and academic motivation. Rienties et al. (2009) have investigated the role of academic motivation in CSCL, i.e., motivation of learners on their contribution to discourse using the Deci and Ryan framework of (intrinsic/extrinsic) motivation. In light of time management, procrastination as in individual differences has been recognized as one of the most important in learning settings (Michinov, Brunot, Le Bohec, Juhel, & Delaval, in press). As for different communication venue, real-time synchronous communication takes greater Internet bandwidth than delayed, asynchronous communication (Lin & Overbaugh, 2009). The obtainability to choose communication modes seems to influence learners' self-efficacy (SE) which consequently affects learning motivation (Brophy, 2004; Zimmerman, 2000). Specifically, the delayed, asynchronous communication typically utilizes discussion board built upon course management systems, blogs or even Wikipedia-type communication tools, whereas synchronous discussions require instant messaging type of tools (Lin & Overbaugh, 2009). With aid of ICT to facilitate hybrid instruction or pure online learning, immediate communication and interaction indeed offers great flexibility. Abrami (2010) offers several suggestions on the rationale to support CSCL using gStudy as an example. First, gStudy as one of the cognitive tools must be designed so the set of tools could increase the learning efficiency and effectiveness. Second, users need more guidance in terms of using those tools. Third, users need drill and practice to integrate the tools nice and wisely. Last, those cognitive tools like gStudy would work better when they are applied as an integral feature within a course or program of study instead of an add-on.

Nonetheless, CSCL modules have come a long way to be embedded in learning management systems. Rienties et al. (2009) have called for further research due to the reasons: (1) contributions to cognitive discourse and the potential solutions are needed; (2) how social interaction, learning processes and outcomes are intertwined in virtual settings; (3) little is known about learners differences regarding the amount and type of discourse contributed in virtual settings. Accordingly, the intent of this research is two-fold: (1) discuss distributed cognition as outcome indicator of CSCL effectiveness; (2) understand the determinants of distributed cognition across the three different communication channels (i.e., synchronous, asynchronous, and virtual reality).

2. Development of Conceptual Model and Propositions

Models are developed through the use of inductive and deductive reasoning, which is integral to accurate conclusion about managerial decisions; the purpose is to increase understanding, prediction, and control of the complexities of present or future conditions (Cooper & Schindler, 2008). Snelbecker (1999) has posited that the development of the model could help apply follow-up theoretical issues, and the concept of a theory refers to *an organized set of propositions that are syntactically and semantically integrated* (p. 33). As an important means

of advancing theories and providing assistance for decision makers (Cooper & Schindler, 2008), a model covers multiple dimensions or perspectives which place learning activities around specific themes or topics (Barker, 2008). To gain better understanding on the intended issues, this study proposes a conceptual model integrating Biggs' *Presage, Process, Product (3P) model* to construct the determinants of distributed cognition in CSCL. To understand the emergent factors related to distributed cognition in the context of CSCL, this study proposes seven propositions stated as follows.

Proposition 1: Learner attributes (LA) has an influence on collaborative practice (CP)

Proposition 2: Instructional attributes (IA) has an influence on collaborative practice (CP)

Proposition 3: Contextual attributes (CA) has an influence on collaborative practice (CP)

Proposition 4: Learner attributes (LA) has an influence on participation

Proposition 5: Collaborative practice (CP) has an influence on distributed cognition (Dcog)

Proposition 6: Participation has an influence on collaborative practice (CP)

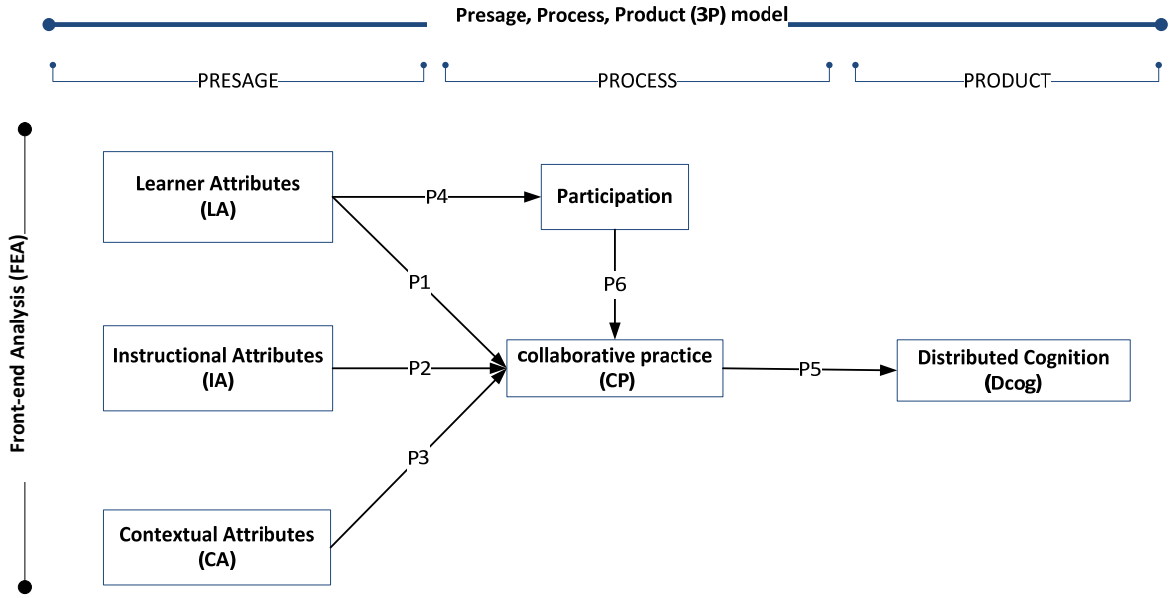

Figure 1. Conceptual model of distributed cognition in CSCL

2.1 Front-end Analysis (FEA)

As a strategy of instructional system design (ISD), front-end analysis (FEA) is an approach to systematically examine prerequisites of intended training sessions and to identify alternatives if difficulties occur during the training sessions. Once training is determined to be necessary, the FEA initiates (Seidel, Kett, & Perencevich, 2007). Given a training session forehand, Instructors as subject matter experts tend to assess learner attributes, instructional attributes, and contextual attributes. Learning diversity has been an indispensable issue when it comes to online environments in which flexible access is offered, and the online environments are considered more responsive to needs of learners. Still, many studies pinpointed that the characteristics or sources related to learning diversity are often neglected in online learning environments (Karin, 2007; Kummerow & Maguire, 2010; Mupinga et al., 2006). There are many different ways to classify learning styles. Sims (2006) posited that one way of classifying learning styles is into these general categories: perceptual modality, information processing, and personality patterns. *Perceptual modalities* define biologically-based reactions to our physical environment and represent the way we most efficiently adopt data (p. 44). *Information processing* distinguishes between the way we sense, think, solve problems, and remember information. *Personality patterns* focus on attention, emotion, and values. It predicts the way individuals will react and feel about different situations (p. 45). Hence, one of the research intents is to understand the extent that learning styles of learner attributes are being considered in CSCL.

2.2 Presage, Process, Product (3P) Model

Proposed by Biggs (1989), the Presage, Process, Product (3P) model refers to an integrated system of three

major phases, and each phase begins with a *p*: hence so-called the *3P* model. The *presage* phase occurs prior to learning. Taking into account of instructional system design, the *presage* phase relate to learner attributes, instructional attributes, and contextual attributes. Next, the *process* phase turns to facilitate learning by planning and delivering instructional interventions. That is, the *process* phase highlights the more significant aspects for learning related to collaborative practice (Freeth & Reeves, 2004). In the *product* phase, learning to collaborate is vital to professional training and development. That is, the anticipated products refer to domain-specific knowledge, skills, attitudes, and collaborative competencies of knowledge management. In his approaches to the enhancement of tertiary instruction, Biggs (1989) noted that understanding learning progress and improvement involves interactive and contextual approaches. His notion was later validated by a couple of studies (Chamorro-Premuzic, Furnham, & Lewis, 2007; Freeth & Reeves, 2004; Zeegers, 2002). Following the Biggs' idea of 3P model applied to teaching and learner learning back in 1989, Biggs, Kember, and Leung (2001) considered the core of instructional system is at the *process* level, in which the learning related activity procedures or does not produce the desired outcomes. They described a generic way to the abovementioned is to gain understanding of what the learners act in their ongoing path and pace.

Freeth and Reeves (2004) utilized the 3P model of learning and teaching to help examine the nature of educational opportunities designed to promote collaborative working. Their gist of their study is to provide a structure to analyze influences upon and within learning opportunities whose purpose is to promote collaborative working from the UK context. They brought up with three major categories under the *presage* level: the learning context; teacher and program developer characteristics; and learner characteristics. First of all, learning context mainly refers to policy & regulation, and resources & logistics—costs and benefits, which are specifically funding, geography & demography, learner numbers, space & time constraints, and curricula demands. Second, teacher and program developer characteristics refer to: (1) conceptions of learning and teaching, (2) perceptions of learners, (3) conceptions of collaborative practice, (4) quality of planning, (5) teacher expertise, and (6) enthusiasm. Last, Learners' presage factors include: their prior learning and beliefs, competing learning needs, and preferences for different ways of learning. Diversity in the learner group also provides opportunities and challenges. In the *process* phase, Freeth and Reeves (2004) considered several factors, i.e., use of educational approaches, the appropriate stage of education, the participation, the duration of educational experiences, the use of distance learning, and issues around offering opt-in, compulsory education, assessment, or facilitation. Lastly in the *product* phase, Freeth and Reeves (2004) defined that the intended products are discipline-specific knowledge, attitudes, behaviors, impact on service delivery and patient/client outcomes, wider-ranging knowledge and know-how, information management, lifelong learning, and collaborative competencies. The Biggs' 3P Model with relevant presage, process and product factors for learning experiences enhances collaborative practice (Freeth & Reeves, 2004).

2.3 Collaborative Competencies and Performance

A number of studies have delineated collaborative competencies considered essential to work with others effectively (Barr, 1998; Calvani et al., 2010; Freeth & Reeves, 2004). As in their study assessing effective collaborative interactions within the add-on module, Forum Plus, for the Moodle™ learning management system (LMS), Calvani et al. (2010) found quantitative methods for content analysis (QCA) are widely used. They also concluded a set of effectiveness indicators to assess collaborative interactions, and proposed the effective interaction model based on two main dimensions, i.e., *participation* and *cohesion*. The indicators for *participation* include extent of participation, proposing attitude, equal participation, and extent of roles, and rhythm. The indicators for *cohesion* include reciprocal reading, depth, and creativity.

Developed by Biggs and Collis, the SOLO Taxonomy is the *Structure of Observed Learning Outcomes* abbreviated its acronym as SOLO hereinafter. It provides descriptions of the structural organization of knowledge at increasingly more complex levels across modes of learning but not content-specific (Boulton-Lewis, 1995). Biggs described a procedure for using the SOLO Taxonomy for assessment in higher education and argued that it would convey appropriate messages about learning by addressing higher level cognitive outcomes and be seen by learners to be doing so (Biggs, 1993). The Structure of Observed Learning Outcomes (SOLO) Taxonomy discusses means of developing and evaluating higher order thinking in Higher Education (Boulton-Lewis, 1995). Boulton-Lewis (1995) related the use of the SOLO Taxonomy to the 3P (Presage, Process, Product) model to find out what learners should know, how learners should trust and believe their own learning, and how learners could assess entering knowledge and learning outcomes in disciplines of interest.

Proposition 1: Learner attributes (LA) has an influence on collaborative practice (CP)

Proposition 2: Instructional attributes (IA) has an influence on collaborative practice (CP)

Proposition 3: Contextual attributes (CA) has an influence on collaborative practice (CP)

2.4 Distributed Cognition (DCog)

To work effectively with others, a number of studies have elaborated a spectrum of collaborative competencies to be considered essential (Barr, 1998; Calvani et al., 2010; Freeth & Reeves, 2004). Referring to the 3P model, the product phase of learning is to be described and evaluated quantitatively, focusing on how much was learned, or qualitatively, focusing on how well and in what way it was learned (Biggs, 1993). In their case study within National Institute for Science Education, Derry, DuRussel, and O'Donnell (1998) presented an evolving distributed cognition theory of interdisciplinary collaboration incorporating both concept of situated cognition and information-processing theory. Lave and Wenger (1996) argued that learning should be a social process in which knowledge is constructed cooperatively, not simply the transmission of abstract and decontextualized knowledge from one individual to another. They also suggested that such learning mechanism should be situated in a defined context and embedded within a particular social environment. The literature reported that the situated learning approach can be successfully applied as a model of instruction (Griffin, 1995; Herrington & Oliver, 1995; Vanderbilt, 1993). Regarding current thinking towards situated learning, Herrington and Oliver (1995) distinguished situated learning from other models of instruction is its critical characteristics. Given that situated learning requires that learners be exposed to authentic social situations, and that the knowledge resulting from that experience is covert, the evaluation of learning turns to be an issue (Tripp, 1996). Aside from real life work situations, computer-based applications are a further step, and criticisms have been level at ICT-assisted materials that claim to use a situated learning framework in their instructional design (Herrington & Oliver, 1995).

The reconceptualization of distributed cognition has been coming along as cloud computing evolves, becoming ubiquitous and inevitable. As a radically new paradigm for rethinking all domains of cognitive phenomena, the Distributed Cognition (abbreviated as DCog) approach was developed by Ed Hutchins and his colleagues at University California, San Diego in the mid to late 80s (Hutchins, 1995). The theoretical and procedural core of the distributed cognition approach derives from the cognitive sciences, cognitive anthropology and social sciences (Hutchins, 1995). Hutchins (1995) proposed DCog in three principle components: (1) Embodiment of information that is embedded in representations of interaction; (2) Coordination of enaction among embodied agents; and (3) Ecological contributions to a cognitive ecosystem.

As Calvani et al. (2010) in their study assessing effective collaborative interactions within the add-on module, Forum Plus, for the Moodle™ learning management system (LMS), they found Quantitative methods for content analysis (QCA) are the ones most widely used. They also concluded a set of effectiveness indicators to assess collaborative interactions, and proposed the effective interaction model based on two main dimensions, i.e., *participation* and *cohesion*. The indicators for *participation* include extent of participation, proposing attitude, equal participation, and extent of roles, and rhythm. The indicators for *cohesion* include reciprocal reading, depth, and creativity to proposals.

There are ways to assess collaborative competencies and performance in CSCL. The *Structure of Observed Learning Outcomes (SOLO) Taxonomy* discusses approaches to understand higher order thinking in Higher Education (Boulton-Lewis, 1995). Boulton-Lewis (1995) applied the use of the SOLO Taxonomy to the *3P model*, and discussed what learners should know and how they believe in their own learning. In particular to assess learning outcomes, Boulton-Lewis (1995) in the findings mentioned that it is substantial to assess entering knowledge in a discipline, to present examples of structural organization of knowledge in a discipline, and to provide models of levels of desired learning outcomes. Biggs (1993) described a procedure for using the SOLO Taxonomy for assessment in higher education and argued that it would inform appropriate messages regarding learning by addressing higher level cognitive outcomes and be seen by learners.

Proposition 4: Learner attributes (LA) has an influence on participation

Proposition 5: Collaborative practice (CP) has an influence on distributed cognition (Dcog)

Proposition 6: Participation has an influence on collaborative practice (CP)

3. Conclusions and Future Research

When applying learning theories to practical course design, Bradley & Oliver (2002) elaborated challenges involved, and indicated how difficult it can be to persuade academics to apply a consistent approach to pedagogy. Gress and Hadwin (2010) noted that learners not only need collaborative tools for learning but also should learn how to use them. Tsai (2010) posited that instructors' initiation could cultivate learners with essential knowledge,

skills, and attitude (KSA), and help learners overcome bottlenecks when climbing the learning curve. After building essential skills and basic knowledge, learners could really benefit from online collaborative learning. One of the goals in higher education is to assist learners to develop a sound knowledge base in the chosen disciplines, and to apply it effectively in further development of knowledge and in professional practices (Boulton-Lewis, 1995). Based on the extensive literature review, the study has achieved the preliminary findings. The finding of this conceptual model lends support to the empirical study by implementing multiple verification strategies. It is suggested that the Delphi technique be applied for qualitative data and a large-scale survey for quantitative data.

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