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Information Sharing to Transformation: Antecedents of Collaborative Networked Learning in Manufacturing

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***Abstract*—**Collaborative networked learning (hereafter CNL) was first proposed by Charles Findley in his work "*Collaborative networked learning: online facilitation and software support*" as part of instructional learning for the future of the knowledge worker. His premise was that through electronic dialogue learners and experts could interactively communicate within a contextual framework to resolve problems, and/or to improve product or process knowledge. Collaborative learning has always been the forefront of educational technology and pedagogical research, but not in the mainstream of operations management. As a result, there is a large disparity in the study of CNL, and little is known about the antecedents of network collaboration and sharing of information among diverse employees in the manufacturing environment. This paper presents a model to bridge the gap between theory and practice. The objective is that manufacturing organizations will be able to accelerate organizational learning and sharing of information through various collaborative

***Keywords*—**Collaborative networked learning, Collaborative technologies, Organizational learning, Synchronous and asynchronous networked learning.

I. Introduction

COLLABORATION begins with the identification of problem and seeking contribution from multiple parties with mutual interest [1], aspirations and purposes to determine which collaboration approach is appropriate [2] in solving operational or engineering challenges. Collaboration is also being defined as a "process of participating in knowledge communities" [3] "in a coordinated, synchronous task to construct and maintain a shared conception of a problem" [4]. CNL occurs when employees and their workgroups learn or attempt to learn through organizational networks and work interactions. Hence, it is a coordinated, synchronous situation in "which a particular form of interaction among people is expected to occur" [5]. It transforms knowledge, experiences and perspectives into a coherent shared understanding and engaged employees in knowledge building [6],[7]. By expanding on these fundamental principles, CNL can be postulated as a pedagogical form of knowledge and information proliferation among members in the networked organizations.

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Further, Goodyear *et al.* [8] refine collaborative learning as a mean to promote interactions between one learner to another; between learners and content experts; between a learning community or workgroups and its learning resources using information communications technology (ICT). In every sense, CNL is a network that is largely autonomous, geographically distributed and heterogeneous, yet it is capable of collaborating complex information to achieve compatible goals [9]. Employees use CNL to proliferate and transform organizational knowledge and learning. This is consistent with Findley's underlying premise of CNL which is based on consensus among members of a group who mutually search for a general understanding on problem resolutions, product or process knowledge, systems and tools [10].

II. Literature Review

A. What is Collaborative Networked Learning

Collaborative learning is not CNL. While collaborative learning addresses pedagogical issues in educational research, CNL's primary focus is in organizational learning and sharing of information, which addresses the process of knowledge acquisition and transformation. In CNL, employees develop and maintain shared conceptions of a subject matter [4], then move swiftly to integrate each other's perspectives and ideas to make sense of a task [11], build new set of knowledge and solve problems [12],[13]. Learning has since evolved from the emphasis on formal training to the experiential learning that is fundamental in CNL. The implementation of lean manufacturing, for instance, has made it necessary for the integration of learning in manufacturing [14],[15].

Some scholars use the term cooperative and collaborative interchangeably to mean employees working interdependently on a common learning task. However, there must be a clear epistemological distinction [16],[17]. Cooperation is accomplished by the division of labour among employees, as an activity where each person is responsible for a portion of the problem solving, whereas collaboration involves the mutual engagement of participants in a coordinated effort to solve the problem together [4],[5]. Both differ by the way in which the task is divided as Camarinha-Matos and Afsarmanesh define cooperation as the aggregated value of the addition individual components each performs part of the job in a quasi-independent manner [9]. In contrast, collaborative shares risks, resources, responsibilities, and rewards in seeking divergent insights, through spontaneity and in an unstructured joint accord [9].

Cooperative learning is not always being embraced because it challenges the established notions of expertise, working identities and relationships based on traditional hierarchies of knowledge [18]. Webb and Palincsar summarize it to say work is ‘cooperation based’ if members shared a divided workload, or ‘collaboration based’ if members develop shared meanings [19]. Knowledge does not necessarily accrue to any individual employee. Instead it is widely distributed across the networks and CNL promotes interaction and sharing of information among diverse members of the manufacturing community.

B. Research Streams in Collaborative Learning

Doherty and Shani identify four broad streams in collaborative research, namely work organization stream, organizational learning stream, learning at work stream and organizational design stream [14]. The work organization stream focuses on organizational workgroups that would enable self-management [20],[21]. Manufacturing is shifting towards greater interdependence among individuals and workgroups to create collective and synergistic products through CNL. The organization learning stream however, addresses the depth and character of the learning process [22],[23], which may be acquired through evaluation, study, experience and innovation. Research approaches such as these examine the conditions under which effective collaborative knowledge building is achieved [24]. Learning at work stream evolved from the emphasis on formal vocational training milieu to the experiential learning of employees and workgroups. Research in the organizational design stream believes that conditions for learning need to be designed and not left to emergence [25]. Others like Cullen et.al [18] and Fuller et.al [26] consider wider span of studies that include regulatory, sectoral environment and characteristics of the operations, e.g. different market conditions, regulations and technology that may influence the way organizations engage with collaborative learning.

C. Collaborative Technologies

CNL leverages on computer technology to provide analytical capabilities, interactivity, and networking support and to organize geographically dispersed teams [27],[28]. In addition, Zakaria, Amelincks and Wilemon in their study on global virtual teams describe how the heterogeneous workgroups used synchronous and asynchronous technologies to collaborate to increase participation and collaboration [29]. The choice of use between synchronous and asynchronous depends on the needs and the stage of collaboration. According to Wasson, before embarking on a project task, the rate of synchronous meetings and frequency of communication were higher than post decision [28]. The asynchronous nature of the post decision work only takes precedence after the need for synchronous meetings had diminished, or members had been reassigned to their respective area of responsibility. It then transforms into more of a cooperative, rather than a collaborative form of work.

D. Asynchronous CNL

Asynchronous communications are more frequent than synchronous because of its flexibility [30] and it does not require employees to be communicating at the same time or in a same workspace. Coordination in asynchronous CNL involves offline data transmission and storage of information, records of interactions and collaborative outcome [31]. This includes use of emails, electronic bulletin boards, wikis, newsgroups, SharePoints, Lotus Notes/Domino, podcasts and discussion forums. Other office applications (including word processor, spreadsheet and presentation) enable CNL with the support of co-authoring and document sharing over the network using Office Web Apps, Google Apps and OneNote to work virtually anywhere with supported browser. While asynchronous computer mediated communication (CMC) tools allow employees to focus on more important tasks and provide freedom to initiate, it poses problem of getting timely information [32]. On the other hand, employees can hold focused discussion with asynchronous conferencing systems about specific issues [33],[34], schedule activities on group calendars [35], track activities through workflow systems [36]; post and retrieve documentation comprising a repository of organizational memory and expertise through hypertext [37]-[39]. The enormous capacity and potential in asynchronous CNL are evident.

E. Synchronous CNL

Synchronous CNL has the capability to contract time which makes it particularly appropriate for tasks that require interactivity, spontaneity, and immediate decision. Synchronous CNL also provides a sense of immediacy and communicative presence and offer both intellectual and emotional support to workgroups [40]. Synchronous CNL occurs when single or multiple parties exchange information concurrently. This would include real-time chatting, exchange of information through group interactive sessions like instant messaging (IM), Microsoft’s NetMeeting, audio-video conferencing like Skype and webcast. Other systems which support real-time collaboration include application sharing, groupware, and online presentation tools. While these systems encourage interaction, they also enable sharing of vital expertise through conversation and discussion [41]. Web conferencing is a powerful tool which provides a platform for geographically dispersed workgroups or virtual teams to collaborate, and exchange of ideas and information. Others using synchronous CNL in the virtual help centres, customer support representatives or helpdesk technicians could remotely collaborate, using chat, email, discussion list, or screen sharing to assist and support customers and employees in their homes and offices, taking advantage of the “anytime”, “anywhere” characteristics of the Internet [42].

F. Application of CNL

The needs to adopt CNL in manufacturing organizations arise from three broad trends: 1) widespread interest in organizational learning, 2) the present commonplace use of

ICT for training, and 3) the ubiquitous presence of workgroups within the organization [43]. These contentions are well supported by many studies which conclude that CNL enables organizations to adapt and respond to global demands for rapid change and greater agility [44]-[47]. In the case of product life cycle (PLC) management, employees interact in dynamic virtual teams for the entire phases from product conceptualization, design, build and servicing [48]. Appropriate manufacturing operations can be assigned to the designated personnel or to the best interest of the virtual consortium [49]. In other words, CNL accelerates product realization by reducing developmental costs, improves organizational performance and responsiveness to market needs.

Virtual teams' collaborations focus on experiential learning that facilitates sharing of knowledge between employees and workgroups [50]. It also helps to develop a culture that foster learning and open sharing of knowledge and innovations. Best practices and transferable processes can be effectively proliferated across the globe, creating new standards and leveraging successes from other organizations or subsidiaries Learn by doing and guided methodology for problem solving could transform organizational knowledge [47]. For instance, CNL allows geographically dispersed employees and workgroups to document, disseminate and share product information such as product schematics, bill of materials (BOM) and technical specifications in the networked environment. Product design and modelling workgroups could work concurrently in the design and analyse the workflow [49]. With global virtual teams, operating cost are further reduced due to cost saving in travelling, relocation and avoid expatriation assignments [51].

On individual perspective, employees are concerned about the needs to acquire new sets of knowledge and skills to improve and to simplify their work processes, increase productivity and to reduce costs of reworks [47]. According to Daradoumis and Marquès, it creates the potential for cognitive and metacognitive benefits [52]. It reinforces and improves learning of the subject-matter and engages employees in the learning process. Likewise, employees who are trained on the use of collaborative tools are able to form new knowledge, enhance their problem solving skills and innovations [47]. CNL also leads to extensive learning opportunity and development in communication and sociotechnical skills.

The issue for discussion is what are the significant antecedents for a Collaborative Networked Learning (CNL) model in manufacturing? Other secondary research questions include: How significant are the relationships between CNL and organizational support, positive interdependence, promotive interaction, and internal-external learning? What is employees' perception of CNL usefulness and effectiveness in manufacturing?

III. Theoretical Model

The model below provides a framework for the study of relationships between the independent variables and dependent variable CNL which will lead to the determination of the antecedents for CNL, as depicted in Fig. 1.

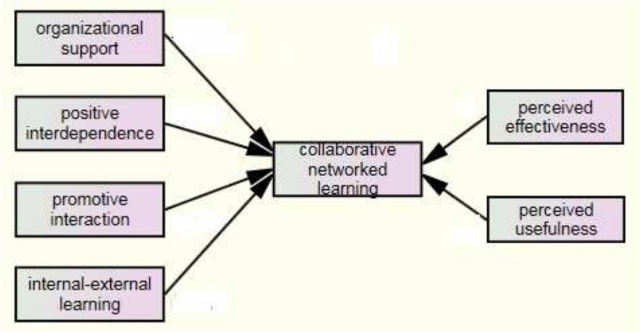

Fig. 1 Conceptual framework for antecedents of CNL

The antecedents for this model are selected from prior studies in technology acceptance model, collaborative learning and cooperative learning (see Appendix A). As antecedents, we consider important events, circumstances, or precursors that transpired before employees in manufacturing organizations are likely to adopt CNL. As such, the proposed framework must be well-grounded and supported with a multi-dimensional approach to sociotechnical theory (STT). The first set of antecedents (organizational support, positive interdependence, promotive interaction, and internal-external learning) analyse the effects on CNL, while the second set of antecedents are concerned with employees' perception on CNL in terms of its effectiveness and usefulness in relation to their work performances.

A. Organizational support

A support system is part of the organizational infrastructure that facilitates the necessary processes to manage, control, coordinate and improve work [53] which must be aligned with the organizational design [54]. Ideally, employees are self-directed and the organization would support their employees' learning goals and engagement with others in the learning networks [26],[55]. Therefore, perceived organizational support are positively related to self-efficacy and motivation to learn [56] and strongly associated with affective commitment [57]. The organization is just as important in determining different forms of knowledge creation, and it influences different forms of learning. Conversely, developing a training system, without organizational readiness and support may lead to failure [58]. Organizational support is deemed to be critical for positive CNL outcomes by providing ample opportunities for diverse employees to engage in collaborative work and learning. The greater the extent to which employees perceived that the organization or management is providing support, the more the employees are willing to learn through collaborative network.

B. Interdependence

It is not unusual for manufacturing organizations to be segmented into functional workgroups. However, as operational issues become more specialised and complex, solutions will require interdependence on others in the organization. Task interdependence may be embedded in the jobs [59] and required contributions from multiple employees [60]. Positive interdependence also relates to the attainment of individual goals to the success of others in the workgroup [61]-[64]. Moreover, a highly interdependent task would require members of the team to work collectively in meeting the project's requirements. Task interdependence increased as the work become more complex and requires assistance and support of others [59]. Many studies are focused on self-managing teams, virtual global teams and other cross functional teams in support of joint quality improvement, efficiency and product development that require some form of interdependence for the workgroups to succeed in their goals.

Interdependencies may shift from communication networks, to collaborative networks involving joint technology development or innovation projects with customers, suppliers and partners [65],[66]. In every sense, building a CNL system requires employees to think in terms of organized networks of mutual interdependence and to overcome individual differences [67]. "When goal, task, resource and role interdependence are clearly understood, employees realize that their efforts are required for the team to succeed"[68]. Positive interdependence facilitates the development of new insights and discoveries through promotive interaction [69]. Employees whose job requires less input from others, requires less information access than those who do [70].

C. Promotive interaction

Social interaction is the key element in CNL; if there is no interaction then there is no real collaboration [71]. Promotive interaction means close, usually synchronous, purposeful activity and joint decision making [61], where employees participate in workgroups to complete their tasks and goals [68]. Kreijns *et a*l. argue that interaction between the workgroups members will not automatically occur just because the technology used allows social interaction [63]. For CNL to occur, both action and interaction need to be well coordinated within the shared workspace in the manufacturing network. It has to be a deliberate planning by the management or organization to promote interaction. In a review of 168 studies between 1924 and 1997 by Johnson, Johnson and Smith, cooperation among learners improved learning outcomes relative to individual work across the board [72]. Their finding is further supported by Springer *et a*l. review on 37 studies of students in science, mathematics, engineering and technology [73]. Engeström explains that through collaborative activities, employees can focus on re-conceptualizing their own interaction system to create new motives and artifacts [74]. Even interactions with computer-supported social networks [75] should be considered as strong interactive. In addition, effective collaboration increases interconnections between organizations [76], increases interactions [77] and foster learning among employees.

D. Internal-external learning

The goal of empirical research is to establish whether and under what circumstances collaborative learning was more effective than learning individually [12]. In a networked organization, the primary activity is participation in collaborative process of sharing and distributing expertise [78]. Effective internal learning requires skill in conducting self-appraisals; ability to use appropriate learning standards and curricula; reflecting the assessment of events and personal goals; and willingness to change learning strategies [79]. However, in a study of dry stone walling by Farrar and Torrey, it was the cooperation and learning with others that was crucial to the success of the learning process [80]. There are cases where employees act as mentors to others and help other employees to see possibilities that were previously inaccessible [58],[81].

Network scholars agree that innovation is a complex process which may require information flow between organizations and employees [82],[83] and innovation could only happen through interaction with external factors [84]. External sources of knowledge are critical to the innovation process and most innovative ideas are learned from either competitor, developers, partners or suppliers. According to Cohen and Levinthal, the ability to learn from external knowledge is mainly a function of skills, language and knowledge of most recent scientific or technological development in the field [85]. This is particular prevalent in technological driven manufacturing organizations that are dependent on their research and development (R&D) teams to capitalize on internal-external knowledge. Wiske, Franz and Breit suggest that "collaboration with others enriches one's capacity to develop and apply ideas" [86](p.99). Employees reflect on what they learned, consider ideas from multiple perspectives to provide an interpretive framework [86] and share organizationally relevant experiences and information with others in collaboration [87]. Therefore, CNL arises from the needs for employees to share, collaborate and learn both internally and externally in order to achieve their goals.

E. Perceived Effectiveness

A study by Murgolo-Poore *et al*. found significant relationship between perceived effectiveness and the amount of information disseminated through the organization's intranet [88]. Effectiveness was operationalized as the usability and usefulness of the information in the repository. Gray and Meister also found that employees who performed more intellectual work and who required frequent interactions with others, perceived themselves to have learned more from knowledge sharing networks than those who are not [70]. As such, employees in the CNL organizations are frequently required to interact and collaborate in workgroups as compared to non-CNL organizations. Frequent communications between workgroups create more opportunities for leveraging competencies, increase perceived effectiveness and increase motivation to collaborate and learn [89],[90].

Employees are required to use the network for documenting and accessing vital information for their work. They are more receptive the collaborative technologies as compare to their counterparts in the non-CNL organizations who have limited resources and mostly rely on tacit knowledge.

F. Perceived usefulness

Employees ability to adopt collaborative technology is dependent on their perceived usefulness [91],[92]. Perceived usefulness is defined as "the prospective user's subjective probability that using a specific application will increase his or her job performance within the organizational context" [91](p.985). If employees perceived that the results gained from using CNL are useful for their work, then employees are more likely to continue using CNL. However, employees bring their own experience and prejudice in adjudging the usefulness of a system and their perceptions are influenced by past experience [92],[93]. Clearly, if CNL does not provide useful information exchanges, it will not motivate employees to collaborate and contribute in the system. At this point, Perkowitz and Etzioni argue that information is useful only if the user considers the information on the network to be accurate, informative and pertinent [94]. Information quality improves the usefulness by enhancing the fit between network content and employees' information requirements [95]. Ritchie *et al.* in their empirical study found that greater level of usefulness will lead to higher levels of intentions to use the Angel software [96]. However, it is our conjecture that employees' perception of usefulness differs between employees in CNL driven organizations and other non-CNL organizations. Employees in CNL organizations may experience more collaborative projects and the complexity of their jobs requires them to share and attain information and knowledge from their peers and workgroups. Therefore, employees in these organizations would most likely to perceive CNL as being useful.

IV. Expected Research Contributions

This study aims to contribute knowledge to CNL in manufacturing. Previous study has focused on knowledge management and organizational learning. The lack of study has been observed and discussed in the literature.

A. Bridging the theory and practice of CNL in manufacturing

This model contributes a theoretical exposition on the roles of theory and practice of CNL. It provides a taxonomy of pragmatic antecedents that links sociotechnical theory (STT) to the practice of CNL in manufacturing. The objective is to provide a framework to understand how employees in manufacturing organizations share and collaborate through complex networks of information systems. Employee learning is becoming part of intricate networked systems that are less formalized and unstructured. In the advent of the virtual factory (VF), manufacturing organizations have extended beyond boundaries of face-to-face communication and collaboration.

Therefore, this paper proposes a theoretically well-grounded development of CNL research that can adequately addresses these issues and challenges in the context of a networked manufacturing environment.

B. Development and validation of the proposed CNL framework for manufacturing

CNL is a recent phenomenon for which no coherent theoretical frameworks yet exists in manufacturing. At present little is known about CNL in manufacturing. De Laat and Lally argue that due to complexities in both the theory and praxis, no single theoretical framework is yet capable of offering a sufficiently powerful articulation of description, rhetoric, inference or application of networked learning [97]. The argument is further supported by Paavola, Lipponen and Hakkarainen that while the present theoretical collaborative learning models complement each other, there are many fundamental differences between these models in terms of both focus and power [98]. The majority of theoretical frameworks are based on educational context. This paper, however, is proposing a framework for CNL within the context of manufacturing as depicted in Fig. 1. In addition, this study also supports Redmond and Lock who suggest that "the focus of the framework is to shift from online learning environments into collaborative and interactive space" [99](p.270). The co-construction of knowledge which is an interdependent process of interaction with social environment [100] should be the emerging force within the framework [99]. This study is hoping to demonstrate such relationships.

C. Development and validation of CNL survey instrument and measurement

Prior studies in collaborative learning merely mirrored the use of computer mediated learning in particularly among participants in learning institutions. It is proposed that a research CNL survey instrument to be developed with measurement scales to study the antecedents of CNL. The survey instrument (see Appendix B) should be complementary to the technology acceptance model (TAM) which is theoretically grounded and posits that perceived usefulness and perceived ease of use are the primary determinants of new technology system adoption.

D. Implications to operational management

Through use of CNL's framework, it is believed that management will provide the impetus to enhance collaborative learning and knowledge sharing in virtual teams. The expansion of collaborative networks and virtual teams are expected to increase the propensity of interactions among manufacturing employees. This study attempts to demonstrate that employees from diverse roles and responsibilities could work collectively and effectively in any networked organizations. Inevitably, employees and their workgroups may become more interdependent in their new roles, given that individuals roles have been intertwined into complex information network within the organization.

Appendix A – Measurement Scales and Constructs Development

Classification of Scale	Authors	Methodology	Sample size	Related construct(s)
Implicit knowledge dissemination	Fedor, Ghosh, Caldwell, Maurer and Singhal (2003)	qualititative (semi structured interview) quantitative (survey)	10 companies, 48 teams, 150 members, response rate 62.5%	organizational support, internal-external learning, project success and impact
Cross-functional teams	Chen and Paulraj (2004)	quantitative	954 sample size, 232 responded response rate 24.3%	top management support, information technology, communication, cross functional teams
Knowledge management system	Vitari, Moro, Ravarini, and Bourdon (2009)	quantitative	103 consultants (response rate 8%), 97 engineers (response rate 20%)	organizational culture, organizational structure, perceived usefulness
Communities of practice	Zboralski (2009)	quantitative (SEM)	1 MNC, 220 active CoP, 222 participants from 36 CoP	management support, interaction frequency, interaction quality
Interdependence (job)	Dean and Snell (1991)	quantitative	512 manufacturing companies, 123 plant managers, 101 operations managers, 109 quality managers, and 97 production managers.	Interdependence
Competitive and collaborative learning	Regueras, Verdu, Verdu and Castro (2011)	quantitative	36 students (in pairs)	positive interdependence
Cooperative learning	Janz and Prasarnphanich (2003)	quantitative (SEM)	13 organizations, 28 teams, 231 teams members	positive interdependence, promotive interaction, effectiveness
Continuous improvement/ learning	Anderson, Rungtusanantham, Schroeder, and Devaraj (1995)	quantitative	41 out of 72 plants participate, 60% response rate	Internal and external cooperation, learning
Continuous improvement	Rungtusanantham, Forza, Koka, Salvador, and Nie (2005)	quantitative (secondary data)	110 plants in Round Two WCM database	Internal and external cooperation, learning
Organizational learning scales	Schroeder, Bates and Junttila (2002)	quantitative (SEM)	164 plants, 65% response rate	Internal and external learning
Knowledge transfer effort	Zellmer-Bruhn (2003)	quantitative	3 companies, 158 teams	knowledge acquisition and transfer, external learning
Team learning	Sarin and McDermontt (2003)	quantitative	52 teams, 229 members	team learning, participation
Learning management system (LMS)	Ritchie, Drew, Srite, Andrews and Carter (2011)	quantitative (SEM)	388 sales associates, 52% from US, 48% from 31 different countries. Response rate 54%	perceived usefulness
Information system	Venkatesh, Speier and Morris (2002)	quantitative (SEM)	not mentioned	perceived usefulness
Organizational knowledge	Bock, Kankanhalli and Sharma (2006)	quantitative (SEM)	44 working profesionals	perceived usefulness

Note: Since there is no prior study in the antecedents of CNL, no measurement has ever been designed. Measurements from other close related researches will be adapted for use.

Appendix B – Survey Questionnaire Items

ORGSUP perceived organizational support	B1	I have access to a computer workstation to perform my job
	B2	I have access to networked computer/email to work with others
	B3	I have access to training and learning through computer network
	B4	I have access to online shared databases to facilitate my work
	B5	I have support from my supervisor/manager to collaborate with others
POSIDP positive interdependence	C1	My job requires me to work in teams
	C2	My job requires me to hold tele-conferences with members from other sites
	C3	My job requires me to share my ideas, work and information with others
	C4	My job can only be completed if other members complete theirs
	C5	My performance depends on the results of my team
PROINT promotive interaction	D1	I frequently share ideas, work and information with others
	D2	I frequently interact with my peers and members in the team online
	D3	I can easily obtained help and support from my team/peers online
	D4	I frequently share information in online meetings or discussions
	D5	Members in the team help each other to learn and engage
LEARN internal-external learning	E1	I learn from shared information from the network
	E2	I received training to enable me to collaborate effectively
	E3	I participate in improvement projects
	E4	I learn from suppliers/customers or external parties
	E5	I learn from my peers and members in the team
PEREFF perceived effectiveness	F1	I work efficiently through use of information from the network
	F2	I work interdependently using the computer network
	F3	I use computers to share information effectively with others
	F4	My team achieved goals for projects by using information from the network
	F5	My team produces good quality collaborative work
PERUSE perceived usefulness	G1	The network systems and tools are useful for my work
	G2	The shared databases are useful for my work
	G3	The online meetings/discussions with external parties are useful
	G4	The network systems are useful for sharing information
	G5	The online learning system and training are useful
COLLRN collaborative learning	H1	I accessed knowledge and information through computer system/network
	H2	I updated my work through the computer system/network
	H3	I learned by sharing and exchanging information with others
	H4	I participated in e-learning or online courses
	H5	I participated in workgroups to complete projects or tasks

Network thinking that recognizes the individual elements of the system enterprise and their reciprocal relationships are becoming increasingly important [101]. As a result, organizational design may be tasked to nurture organizational development and other essential networking skills.

V. Conclusion

The research on collaborative networked learning (CNL) explores the antecedents to knowledge and information sharing and transformation among employees in manufacturing organizations. It provides a framework for future research on the theory of organizational learning and sociotechnical theory, in particular interest of diverse manufacturing environment which is constantly evolving as a consequence of technological advancement. This research, hope to contribute a sound theoretical knowledge for collaborative networked learning with possibilities to support both comparative and empirical researches in areas of collaborative technologies, employees engagement, online learning, virtual teams and knowledge transformation.

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References

[1] S.A. Mohrman, A.M. Mohrman Jr, S.G. Cohen, and S.Winby, "The collaborative learning cycle: Advancing theory and building practical design frameworks through collaboration". In A. B. Shani, S. A. Mohrman, W. A. Pasmore, B. Stymne, and N. Adler (Eds.), *Handbook of Collaborative Management Research*. Singapore: Sage, 2008, pp.509-530.

[2] A.B. Shani, S.A. Mohrman, W.A. Pasmore, B. Stymne, and N. Adler, *Handbook of Collaborative Management Research.* Singapore: Sage, 2008.

[3] L. Lipponen, "Computer support for collaborative learning". *Proceedings of the Conference on Computer Support for Collaborative Learning: Foundations for a CSCL Community. International Society of the Learning Sciences*, 72-81. , 2002, pp.73

[4] J. Roschelle, and S. Teasley, (1995). The construction of shared knowledge in collabrative problem solving. In C. E. O'Malley (Ed.), *Computer supported collaborative learning.* (pp. 69-96.). Heidelberg: Springer-Verlag. pp.70.

[5] P. Dillenbourg, "What do you mean by collaborative learning?" In P. Dillenbourg (Ed.), *Collaborative-Learning: Cognitive and Computational Approaches* (pp. 1-19). Oxford: Elsevier, 1999, pp.9

[6] D. McConnell, "Examining a collaborative assessment process in networked lifelong learning". *Journal of Computer-Assisted Learning, 15*(3), 1999, pp.232-243.

[7] P. Van den Bossche, M. Segers, and P.A. Krischner, "Social and cognitive factors driving teamwork in collaborative learning environments". *Small Group Research, 37*, 2006, pp. 490-521.

[8] P. Goodyear, S. Banks, V. Hodgson, and D. McConnell, *Advances in research on networked learning*: Kluwer Academic Publisher, 2004.

[9] L.M. Camarinha-Matos, and H. Afsarmanesh, "Knowledge enterprise: Intelligent strategies in product design, manufacturing and management". *International Federation for Information Processing (IFIP), 207*, 2006, pp.26-40.

[10] C.A. Findley, *Collaborative Networked Learning: On-line Facilitation and Software Support*. Burlington, MA: Digital Equipment Corporation, 1988.

[11] B.K. Nastasi, and D.H. Clements, "Social-cognitive behaviors and higher-order thinking in educational computer environments". *Learning and Instruction, 2*, 1992, pp.215-238.

[12] P. Dillenbourg, M. Baker, A. Blaye, and C. O'Malley, "The evolution of research on collaborative learning". In E. Spada & P. Reiman (Eds.), *Learning in Humans and Machine: Towards an interdisciplinary learning science.* (pp. 189-211). Oxford: Elsevier, 1996.

[13] J.E. McGrath, *Groups: Interaction and performance*. Englewood Cliffs: Prentice-Hall, 1984.

[14] P. Docherty, and A.B. Shani, "Learning mechanism as means and ends in collaborative management research". In A. B. Shani, S. A. Mohrman, W. A. Pasmore, B. Stymne, & N. Adler (Eds.), *Handbook of Collaborative Management Research.* (pp. 163-181). Singapore: Sage, 2008.

[15] T. Fenwick, and K. Rubenson, *Taking stock: A review on research on learning in work, 1999-2004.* presented at the meeting of the Paper presented at the Forth International Conference on Research on Work and Learning., University of Technology, Sydney, 2005.

[16] K.A. Bruffee, "Sharing Our Toys: Cooperative Learning versus Collaborative Learning". *Change, 27*(1), 1995, pp. 12-18.

[17] J.L. Flannery, "Teacher co-conspirator: Knowledge and authority in collaborative learning". In K. Bosworth & S. J. Hamilton (Eds.), *Collaborative learning: Underlying process and effective techniques. New direction for teaching and learning, No.59*. San Franciso: Jossey-Bass, 1994, pp. 15-23.

[18] J. Cullen, K. Hadjivassiliou, E. Hamilton, J. Kelleher, E. Sommerlad, and E. Stern, "Review of current pedagogic research and practice in the fields of post-compulsory education and lifelong learning" *(final report submitted to the Economic and Social Research Council).* London: The Tavistock Institute, 2002.

[19] N.M. Webb, and A.S. Palincsar, "Group processes in the classroom". In D. Berliner & R. Calfee (Eds.), *Handbook of educational psychology*. New York: Macmillian, 1996, pp. 841-873.

[20] M. Emery, *Searching in new directions in new ways for new times.* Canberra, 1982.

[21] B. Gustavsen, *Dialogue and development*. Assen/Maastricht, Netherlands: van Gorum, 1992.

[22] W.N. Issacs, "Taking flight: Dialogue, collective thinking, and organizational learning". *Organizational Dynamics, 22*(2), 1993, pp.24-39.

[23] P.M. Senge, *The Fifth Discipline: The Art and Practice of the Learning Organization*. New York.: Doubleday, 1994.

[24] M. Baker, E. de Vries, and K. Lund, "Designing computer-mediated epistemic interactions". *Proceedings of the 9th International Conference on Artificial Intelligence in Education (AI-ED 99)*, 1999, pp.139-146.

[25] R.Lipshitz, M. Popper, and S. Oz, "Building learning organizations: The design and implementation of organizational learning mechanisms". *Journal of Applied Behavioral Science, 32*(2), 1996, pp.292-305.

[26] A. Fuller, L. Unwin, A. Felstead, N. Jewson, and K. Kakavelakis, "Creating and using knowledge: An analysis of the differentiated nature of workplace learning environments". *British Educational Research Journal, 33*(5), 2007, pp. 743-759.

[27] D. Suthers, R. Vatrapu, R. Medina, S. Joseph, and N. Dwyer, "Beyond threaded discussion: Representational guidance in asynchronous collaborative learning environments". *Computer & Education, 50*(4), 2008, pp.1103-1127.

[28] B. Wasson, "Design and use of collaborative network learning scenarios: The DoCTA experience". *Educational Technology & Society, 10*(4), 2007, pp. 3-16.

[29] N. Zakaria, A. Amelinckx, and D. Wilemon "Navigating across culture and distance: Understanding the determinants of global virtual team performance". In V. I. Sessa & M. London (Eds.), *Work group learning,* New York, London: Lawrence Erlbaum Associates, 2008, pp. 175-192.

[30] L. Wilson, and J. Salmons, "Online collaborative integration and recommendation for future research. In J. Salmons & L. Wilson (Eds.), *Handbook of Research on Electronic Collaboration and Organizational Synergy*. Vol. 2. New York: Information Science Reference, 2009, pp. 757-767.

[31] G. Balmisse, D. Meingan, and K. Passerini, "Selecting right knowledge management tools: Software trends and key evaluation criteria". In M. E. Jennex (Ed.), *Knowledge Management Organizational Memory, and*

Transfer Behaviour. New York: Information Science Reference, 2009, pp. 270-280.

[32] G. Lee, and S. Holmquist, (2009). Overview on Information Systems and Tools for Collaborative Enterprise: Business Impacts and Managerial Issues. In J. Salmons & L. Wilson (Eds.), *Handbook of Research on Electronic Collaboration and Organizational Synergy.* (Vol. 2). New York: Information Science Reference, 2009, pp.435-450.

[33] L. Sproull, and S. Kiesler, *Connections: New ways of working in networked organization*. Cambridge, MA: The MIT Press, 1991.

[34] M. Turoff, "Computer mediated communication requirements for group support". *Journal for organizational computing, 1*, 1991, pp. 85-113.

[35] B. Lange, "Electronic group calendaring: Experience and expectations". *Proceedings of Groupware 1992*, 1992, pp. 428-432.

[36] K. Abbot, and S. Sarin, "Experience with workflow management: Issues for the next generation". *Proceedings of the ACM Conference on Computer-Supported Cooperative Work (CSCW'94)*, 1994, pp. 113-120.

[37] M.S. Ackerman, "Augmenting the organizational memory: A field study of answer garden". *Proceedings of the ACM Conference on Computer-Supported Cooperative Work (CSCW'94)*, 1994, pp. 243-252.

[38] M.S. Ackerman, T.W. Malone, "Answer garden: A tool growing organizational memory". *Proceedings of the ACM Conference on office information systems*, 1990, pp. 31-39.

[39] J. Conklin, "Capturing organizational memory". *Proceedings of Groupware 1992*, 1992, pp. 133-137.

[40] C. Haythornthwaite, M. Kazmer, J. Robins, J., and S. Shoemaker, S. "Community development among distance learners: Temporal and technological dimensions". *Journal of Computer Mediated Communication, 6*(1), 2000.

[41] R. Hass, W. Aulbur, and S. Thakar, "Enabling communities of practice at EADS Airbus". In M. S. Ackermann, P. Volkmar, & V. Wolf (Eds.), *Sharing Expertise: Beyond Knowledge Management.* Cambridge: The MIT Press, 2003, pp. 179-198.

[42] L.R. Irons, "The Limits of Anytime, Anywhere Customer Support". In J. Salmons & L. Wilson (Eds.), *Handbook of Research on Electronic Collaboration and Organizational Synergy* (Vol. 2). New York: Information Science Reference, 2009, pp. 500-515.

[43] D.P. Brandon, and A.B. Hollingshead, "Collaborative knowledge and training in online groups". In V. I. Sessa & M. London (Eds.), *Work group learning*. New York, London: Lawrence Erlbaum Associates, 2008, pp. 285-314.

[44] I. Bogenrieder, and B. Nooteboom, "Learning groups: What types are there? A theoretical analysis and empirical study in a consultancy firm". *Organizational Studies, 25*(2), 2004, pp. 287-313.

[45] L. Knight, and A. Pye, "Network learning: An empirically derived model for learning by groups of organizations". *Human Relations., 58*(3), 2005, pp.369-392.

[46] Polito, T., & Watson, K. "Towards a interdisciplinary organizational framework". *Journal of American Academy of Business, 2*(1), 2002, pp. 162.

[47] W.H. Quik, and M.L. Yeong, *Developing Organizational Capability through Collaborative e-Learning: A Case Study of Eaton Electric Switchgear*. presented at the meeting of the International Conference on Distance, Collaborative and e-Learning (DCEL 2006). Kuala Lumpur, 2006.

[48] J.Y. Sayah, and L. Zhang, "On-demand business collaboration enablement with web services". *Decision support systems, 40*, 2005, pp. 107-127.

[49] H.F. Zhan, W.B. Lee, C.F. Cheung, S.K. Kwok, and X.J. Gu, "A web-based collaborative product design platform for dispersed network manufacturing". *Journal of Materials Processing Technology*(138), 2003, pp. 600–604. doi:DOI:10.1016/S0924-0136(03)00156-0

[50] E. Valkanos, and I. Fragoulis, "Experiential learning—its place in in-house education and training". *Development and Learning in Organizations, 21*(5), 2007, pp. 21–23.

[51] D. Duarte, and N.T. Snyder, *Mastering virtual teams: Strategies, tools and techniques that succeed* (3 ed.). San Francisco: Jossey-Bass/John Wiley & Sons Inc., 1999.

[52] T. Daradoumis, and J.M. Marquès, *A methodological approach to networked collaborative learning: Design and pedagogy issues*. 2000.

[53] S.A. Mohrman, S.G. Cohen, and A.M. Mohrman Jr, *Designing team based organizations: New forms for knowledge work*. San Francisco: Jossey-Bass, 1995.

[54] C.L. Harris, and M.M. Bayerlein, (2003). Team-based organization: Creating an environment for team sucess. In M. A. West, D. Tjosvold, & K. G. Smith (Eds.), *International handbook of organizational teamwork and cooperative working*. Sussex, England: John Wiley and Sons Ltd., 2003, pp. 187-209

[55] P.J. Smith, "Workplace Learning and Flexible Delivery". *Review of Educational Research, 73*(1), 2003, pp.53-88.

[56] D.S. Chiaburu, K. Van Dam, and H.M. Hutchins, "Social support in the workplace and training transfer: A logitudinal analysis". *International Journal of Selection and Assessment, 18*(2), 2010, pp. 187-200.

[57] C. Aube, V. Rousseau, and E.M. Morin, "Perceived organizational support and organizational commitment: The moderating effect of locus of control and work autonomy". *Journal of Managerial Psychology, 22*(5), 2007, pp. 479-495.

[58] Billett, S., "Learning through work: Workplace affordances and individual engagement". *Journal of Workplace Learning, 13*(5), 2001, pp. 209-214.

[59] G. Van der Vegt, and E. Van de Vliert, "Intragroup interdependence and effectiveness: A review and proposed directions for theory and practice". *Journal of Managerial Psychology, 17*(1), 2001, pp.50-67.

[60] R. Wageman, "The meaning of interdependence". In M. E. Turner (Ed.), *Groups at work: Theory and research*. New Jersey: Lawrence Erlbaum Associates, 2001, pp 197-217.

[61] M. D'eon, "A blueprint for interprofessional learning". *Journal of Interprofessional Care, Supplement 1*, 2005, pp.49-59.

[62] D.W. Johnson, and R. Johnson, *Cooperation and competition: Theory and research*. Edina: Interaction Book Company, 1989.

[63] K. Kreijns, P.A. Kirschner, and W. Jochems, "Identifying the pitfalls for social interaction in computer-supported collaborative environment: A review of the research". *Computer in Human Behavior, 19*, 2003, pp. 335-353.

[64] G. Young, "Contexualizing cooperation". In M. A. West, D. Tjosvold, & K. G. Smith (Eds.), *International handbook of organizational teamwork and cooperative working*. West Sussex, England: Wiley, 2003.

[65] E. Giuliani, "The selective nature of knowledge networks in clusters: Evidence from wine industry". *Journal of Economic Geography, 7*(2), 2007, pp. 139-168.

[66] C. Lechner, M. Dowling, and I. Welpe, "Firm networks and firm development: The role of relational mix". *Journal of Business Venturing, 21*, 2006, pp. 514-540.

[67] C. Heckscher, *The collaborative enterprise: Managing speed and complexity in knowledge-based businesses*. New Haven, London: Yale University Press, 2007.

[68] D.W. Johnson,and R.T. Johnson, "Training for cooperative group work". In M. A. West, D. Tjosvold, & K. G. Smith (Eds.), *International handbook of organizational teamwork and cooperative working*. Sussex, England: John Wiley & Sons Ltd. 2003, pp. 174.

[69] B. Gabbert, D. Johnson, and R. Johnson, "Cooperative learning, group to individual transfer, process gain and the acqusition of cognitive reasoning strategies". *Journal of Psychology, 120*(3), 1986, pp. 265-278.

[70] P.H. Gray, and D.B. Meister, "Knowledge sourcing effectiveness". *Management Science, 50*, 2004, pp.821-834.

[71] A.L. Soller, A. Lesgold, F. Linton, and B. Goodman, "What makes peer interaction effective? Modeling effective communication in an intelligent CSCL". *Proceedings of the 1999 AAAI Fall Symposium: Psychological Models of Communication in Collaborative System*, 1999, pp. 116-123.

[72] D.W. Johnson, R.T. Johnson, and K. Smith, *Active learning: Cooperation in the college classroom* (2 ed.). Edina: Interaction Book Co, 1998.

[73] L. Springer, M. Stanne, S. Donovan, Effect of small group learning on undergraduates in science, mathematics, engineering and technology: A meta-analysis. *Review of Educational Research, 69*(1), 1999, pp. 21-52.

[74] Y. Engeström, *Interactive expertise. Studies in distributed working intelligence*, 1992.

[75] B. Wellman, J. Salaff, D. Dimitrova, L. Garton, M. Gulia, and C. Haythornthwaite, "Computer networks as social networks: Collaborative work, telework, and virtual community". In E. L. Lesser, M. A.

Fontaine, & J. A. Slusher (Eds.), *Knowledge and Communities*. Boston: Butterworth-Heinemann, 2000, pp. 179-207.

[76] K.G. Provan, and H.B. Milward, (1995). A preliminary theory of interorganizational network effectiveness: A comparative study of four community of mental health systems. *Adminstrative Science Quarterly, 40*(1), 1-33.

[77] B. Chen, "Antecedents or processes? Determinants of perceived effectiveness of interorganizational collaboration for publc service delivery". *International Public Management Journal, 13*(4), 2011, pp. 381-407.

[78] A.L. Brown, and J.C. Campione, "Guided discovery in a community of learners". In M. K. (Ed.), *In classroom lessons: Integrating cognitive theory and classroom practice*. Cambridge, MA: MIT Press, 1994.

[79] J. Cortina, S. Zaccaro, L. McFarland, K. Baughman, and G. Wood, *Promoting realistic self-assessment as a basis of effective leader self development (ARI Reserach Note 2004-05)*. Crystal City: United States Army Research Institute for Behavioral and Social Sciences, 2004.

[80] N. Farrar, and G. Trorey, "Maxims, tacit knowledge and learning: Developing expertise in dry stone walling". *Journal of Vocational Education and Training, 60*(1), 2008, pp. 35-48.

[81] D. Dymock, and R. Gerber, "Unintegrated training? Exploring links between off- and on-the-job learning" *Education + Training, 44*(1), 2002, pp. 23-30.

[82] U. Lichtenthaler, "External commercialization of knowledge: Review and research agenda". *International Journal of Management Reviews, 7*, 2005, pp. 231-255.

[83] K. Meagher, and M. Roger, "Network density and R&D spillovers". *Journal of Economic Behavior and Organization, 53*, 2004, pp. 237-260.

[84] H. Chesbrough, (2003). *Open innovation: The new imperative for creating and profiting from technology*. Boston, MA: Harvard Business School Press, 2003

[85] W.M. Cohen, and D.A. Levinthal, "Absorptive capacity: A new perspective on learning and innovation". In R. Cross & S. Israelit (Eds.), *Strategic learning in a knowledge economy: Individual, collective, and organizational learning process*. Boston, Oxford: Butterworth Hienemann, 2000.

[86] M.S. Wiske, K.R. Franz, and L. Breit, "Teaching for understanding with technology". In. San Francisco: Jossey-Bass, 2005.

[87] C.P. Lin, "To share or not to share: Modeling tacit knowledge sharing, its mediator and antecedents". *Journal of Business Ethics, 70*(4), 2007, pp.411-428.

[88] M.E. Murgolo-Poore, L.E., Pitt, P.R. Berthon, and G. Prendegast, "Corporate intelligence dissemination as the concequence of intranet effectiveness: An empirical study". *Public Relations Review, 29*, 2003, pp. 171-184.

[89] L.F. Monteiro, N. Arvidsson, and J. Birkinshaw, "Knowledge flows within multinational corporations: Explaining subsidary isolation and its performance implications". *Organization Science, 19*(1), 2008, pp. 90-107.

[90] N. Noorderhaven, and A-W. Harzing, "Knowledge-sharing and social interaction within MNEs". *Journal of International Business Studies, 40*, 2009, pp. 719-741.

[91] F.D. Davis, "Perceived usefulness, perceived ease of use and user acceptance of information technology". *MIS Quarterly, 13*(3), 1989, pp. 319-339.

[92] G.S. Iyer, and S. Ravindran, S. "Usefulness, incentives and knowledge management". *Journal of Knowledge Management, 13*(6), 2009, pp. 410-430.

[93] S. Dasgupta, M. Granger, and N. McGarry,. "User acceptance of e-collaboration technology: An extention of the technology acceptance model". *Group Decision and Negotiation, 11*, 2002, pp. 87-100.

[94] M. Perkowitz, and O. Etzioni, "Towards adaptive website: Conceptual framework and effectiveness". *Computer Networks, 31*(11), 1999, pp.1245-1258.

[95] H. Lin, "The role of online and offline features in sustaining virtual communities: An empirical study". *Internet Research, 17*(2), 2007, pp.119-138.

[96] W.J. Ritchie, S.A. Drew, M. Srite, P. Andrews, and J.E. Carter, "Application of a learning management system for knowledge management: Adoption and cross-cultural factors". *Knowledge and Process Management, 18*(2), 2011, pp.75-84.

[97] M. de Laat, and V. Lally, "Complexity, theory and praxis: Researching collaborative learning and tutoring processes in a networked learning community". *Journal of Instructional Science, 31*(1-2), 2003, pp. 7-39.

[98] S. Paavola, L. Lipponen, and K. Hakkarainen, K. "Epistemological Foundations for CSCL: A Comparison of Three Models of Innovative Knowledge Communities". In G. Stahl (Ed.), *Computer Support for Collaborative Learning: Foundations for a CSCL Community* (pp. 24-32). New Jersey: Lawrence Erlbaum Associates, 2002, pp. 24-32.

[99] P. Redmond, and J.V. Lock, "A flexible framework for online collaborative learning". *Internet and Higher Education, 9*, 2006, pp. 267-276.

[100] J. Valsiner, *Culture and human development*. London: Sage publication, 2000.

[101] A. Picot, R. Reichwald, and R.Wigand, (2008). *Information, organization and management*. Munich, Germany: Springer.