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Influential Factors of Collaborative Networks in Manufacturing: Validation of a Conceptual Model

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Abstract

The purpose of the study is to identify influential factors in the use of collaborative networks within the context of manufacturing. The study aims to investigate factors that influence employees' learning, and to bridge the gap between theory and praxis in collaborative networks in manufacturing. The study further extends the boundary of a collaborative network beyond enterprises to include suppliers, customers, and external stakeholders. It provides a holistic perspective of collaborative networks within the complexity of the manufacturing environment, based on empirical evidence from a questionnaire survey of 246 respondents from diverse manufacturing industries. Drawing upon the socio-technical systems (STS) theory, the study presents the theoretical context and interpretations through the lens of manufacturing. The results show significant influences of organizational support, promotive interactions, positive interdependence, internal-external learning, perceived effectiveness, and perceived usefulness on the use of collaborative networks among manufacturing employees. The study offers a basis of empirical validity for measuring collaborative networks in organizational learning and knowledge/information sharing in manufacturing.

Keywords: Employees' learning, collaborative networked learning, collaborative networks, socio-technical systems theory

Introduction

The study uses the "network" metaphor in a broader perspective to describe the integral and networked organization that

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connects its employees, customers, suppliers, and partners. According to Addleson (2013), a network is a "hodgepodge of people with varying interests, motives, and levels of commitment, as well as diverse specializations, who may report to bosses with different agendas" (p. 38). Boot and Reynolds (1997) suggest using a multifaceted concept such as "network", rather than viewing organizations in terms of groups, to reflect the dynamic nature of work organizations and the way learning is organized. It enables researchers to think fundamentally about any manufacturing organization as a network that supports patterns of activities related to manufacturing operations. The increase of outsourcing and intricate supply chain also creates more dependence on networks (Basu, 2001). According to Camarinha-Matos and Afsarmanesh (2006a), a network consists of a variety of entities that are autonomous, geographically distributed, and heterogeneous in terms of their operating environment, culture, socio-capita, and goals, yet their interactions are well supported by computers to collaborate and to achieve common goals.

These connections have to be recognized and negotiated before employees can work at collaborating (Addleson, 2013). Figure 1 illustrates the transformation from individual learning to learner-expert mentoring (or an apprenticeship scheme), and finally to the emergence of a collaborative network.

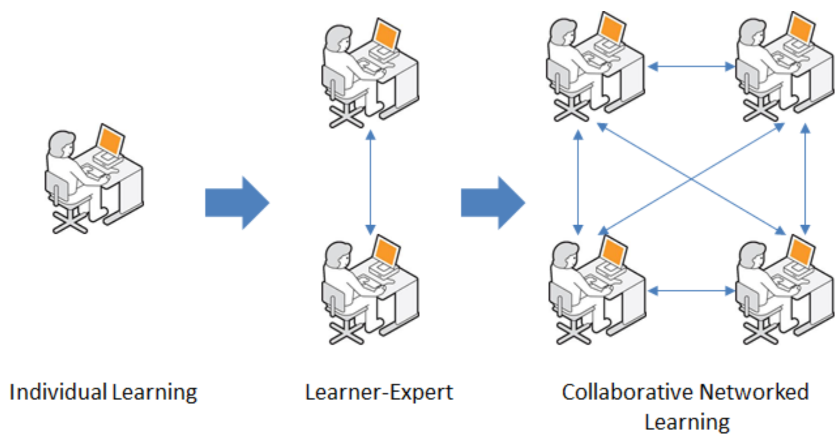

Figure 1: Transformation from individual learning to collaborative networked learning

Collaborative networks form an integral part of individual and organizational learning, contributing information and knowledge in their different roles and reference domains. In this context, collaboration promotes interactions between one learner and another, between learners and content experts, and between a learning community or workgroups and their learning resources through information communication technology (Brophy, 2001; de Laat, 2006; Goodyear, 2000; Goodyear et al., 2004; Goodyear et al., 2005; Jones & Esnault, 2004). The term "collaborative networked learning" (CNL) reflects the essence of learning in an organization using computer networks to share information and knowledge. This concept is notably supported by Jones and Esnault (2004) and Camarinha-Matos and Afsarmanesh (2006a), and hence serves as the basis for this study.

Research Problem

There is a lack of study in the area concerning collaborative networks in manufacturing. At present, the theoretical foundation is borrowed and adapted from other disciplines such as collaborative learning. Many scholars agree that studies on collaborative networks need to be firmly grounded in appropriate theoretical approaches and analytic perspectives to increase its rigor and relevance (de Laat & Lally, 2004; de Laat et al., 2006; Hakkinen et al., 2003; Hodgson & Watland, 2004; Stahl, 2004). Theoretical grounding and empirical research from other disciplines may not be directly applicable to manufacturing.

Research Objective

The primary aim of this study is to identify influential factors in the use of collaborative networks within the context of manufacturing. At present, there is a lack of knowledge concerning the factors that promote the sharing of information and collaboration in the manufacturing industry. Henceforth, the objective of this study is to identify influential factors in the use of collaborative networks and to bridge the gap between theory and praxis. In order to achieve this objective, the study needs to pay close attention to numerous events, activities, and tasks that motivate employees in diverse manufacturing organizations to share information and to collaborate.

Literature Review

In today's manufacturing environment, there is a significant emphasis on multi-organizational collaboration, thus knowledge sharing is becoming part of an intricate network, unrestricted by geographical boundaries. With information highly distributed through organizations, it has become paramount for enterprises to focus on information management to improve knowledge construction (Achrol & Kotler, 1999), and to adapt effectively to constantly changing environments (Lusch et al., 2010). Collaborative networks could provide the means for sharing and integrating knowledge, and for enabling diverse teams to collaborate. Collaborative networks can manifest in many forms and functions, including virtual enterprises, virtual teams, networks of practice, and other technical and non-technical collaboratories.

Collaboration involves intra- and inter-organization (customers and suppliers, or nodes in a network) sharing information to make forecasts (McCarthy & Golicic, 2002; Poler et al., 2008) and improving inventory performance throughout the manufacturing organizations (Rubiano & Crespo, 2003). The Knowledge and Learning in Advanced Supply Systems (KLASS) project focused on the automotive and aerospace industries to develop networks of collaboration with suppliers (Rhodes & Carter, 2003). Web-centred learning has supported the development of e-commerce capabilities and network group learning between linked workplaces. Inter-organizational collaborative networks improve the sharing of information between extended manufacturing enterprises (EME) (Coghlan & Coughlan, 2006), and by expanding to customer-supplier relationships, the networks enhance overall EME performance (Nielsen et al., 2008). The best practices lend themselves to the process-oriented view of knowledge management, whilst the performance measurement applies directly to a resource-based view of the organization with knowledge as a valuable asset (Truch et al., 2000).

Collaboration begins with the identification of a problem and seeking contribution from multiple parties with mutual interest (Addleson, 2013; Camarinha-Matos et al., 2006a; Dillenbourg, 1999; Dillenbourg et al., 1996; Mohrman et al., 2008), and with aspirations and purposes to determine which collaboration approach is appropriate (Shani et al., 2008) in solving operational or engineering tasks. Collaboration has also been defined as a "process of participating in knowledge communities" (Lipponen, 2002a, p. 73) "on a coordinated, synchronous task to construct and maintain a shared conception of a problem" (Roschelle & Teasley, 1995, p. 70). Collaboration transpires when employees and their workgroups learn, or attempt to learn, through organizational networks, work interactions, and projects by reciprocal collaboration. Collaboration transforms knowledge, experiences, and perspectives into a coherent shared understanding and engages employees in knowledge construction (McConnell, 1999; Van den Bossche et al., 2006).

Theoretical Background

The central principles of the socio-technical systems theory were first elaborated by Trist and Bamforth (1951). Luhmann (1993) advanced the approach by modelling collaborative work based on new epistemological concepts in combination with the systems theory. The term "socio-technical systems” (STS) relates to systems that combine social and technical sub-systems and interactions between complex system infrastructures and human behaviour. In a study of the influential factors that affect the intention to adopt collaborative technologies in the construction industry, Nikas, Poulymenakou, and Kriaris (2006) considered all the prerequisite resources that an organisation must possess in order to adopt a novel technology. Influential factors were found to include all the internal factors, external factors, and perceived benefits that affected the decision to adopt novel technology (Nikas et al., 2006, p. 632). The decision to collaborate is influenced by internal and external factors as well as the ability for technologies to support accomplishment of work objectives.

The existing models and frameworks characterize effective group interaction, sharing of information, and construction of knowledge in terms of the following elements: organizational support (Fuller et al., 2007; Harris & Bayerlein, 2003; Mohrman et al., 1995; Scott & Walczak, 2009; Smith, 2003), positive interdependence (Chatenier et al., 2009; Giuliani, 2007; Grant & Baden-Fuller, 2004; Johnson & Johnson, 2003; Lechner et al., 2006; Lusch et al., 2010; Van der Vegt & Van de Vliert, 2001; Wageman, 2001), promotive interaction (Benbunan-Fich et al., 2003a; Soller & Lesgold, 2000; Swan, 2005; Whatley et al., 2005), internal-external learning, perceived effectiveness, and perceived usefulness. The study proposes to take a step further by investigating these elements (as potential factors) to determine their influence in collaborative networks.

Figure 2 presents a conceptual model of the influential factors expected to affect collaboration in manufacturing. Specifically, the model suggests that these factors may influence employees’ use of collaborative networks for their work and projects.

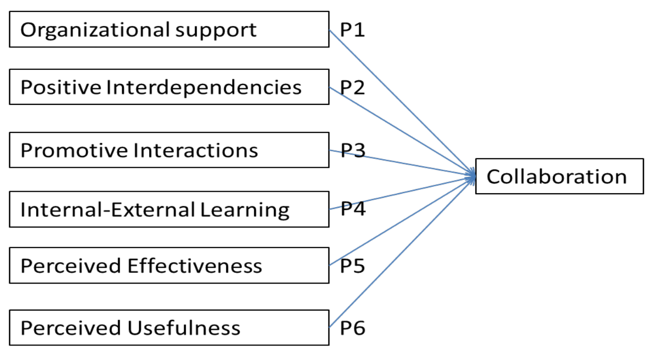

Figure 2: Conceptual model of influential factors

Organizational Support

Organizational support in information systems is defined in terms of assistance, feedback, encouragement, and the provision of procedural support (Scott et al., 2009). A support system is part of the organizational infrastructure that facilitates the necessary processes to manage, control, coordinate, and improve work (Mohrman et al., 1995), which must be aligned with the organizational design (Harris et al., 2003). Manufacturing organizations not only determine the system architecture and enterprise information system (EIS), but they also influence the forms of knowledge construction and the ability to share information using technology as a mediator. Thus, it can be postulated that:

Proposition 1: Organizational support influences collaborative networks

Positive Interdependencies

According to Findley (1988), learners share a common purpose, but at the same time are dependent on each other and accountable for individual and group successes of their work or projects.

Learning theories state that interdependencies between team members are necessary for achieving desired learning outcomes (Chatenier et al., 2009). Conversely, task interdependence is embedded in the jobs (Van der Vegt et al., 2001), and employees require assistance and support from multiple teams to work collectively (Van der Vegt et al., 2001; Wageman, 2001). Studies have shown that self-managing teams, virtual global teams, and other cross-functional teams that support joint improvement activities and new product development (Grant et al., 2004) demand positive interdependence for collaborative works to succeed.

Proposition 2: Positive interdependencies influence collaborative networks

Promotive Interactions

Without interaction, there is no real collaboration (Soller et al., 1999). According to Lowyck and Poysa (2001), knowledge emerges through the network of interactions and is distributed among employees who interact. Hence, learning is viewed as a social construct, facilitated by communication, interaction, collaboration, and cooperation among employees (Benbunan-Fich & Hiltz, 2003b; Swan, 2005). The degree of collaboration relies on the joint and shared ownership of the outcome and the quality of interaction during the process (Whatley et al., 2005). Therefore, promotive interactions precede all form of collaborations.

Proposition 3: Promotive interactions influence collaborative networks

Internal-External Learning

According to Paiva, Roth, and Fensterseifer (2008), internal knowledge development leads manufacturing organizations to continuously fit their capabilities to environmental changes. Internal learning resides within the organization, embedded in behaviour, manufacturing activities, procedures, data storage, interactions, and repositories of knowledge. Direct experience and interaction are the only ways tacit knowledge can be transferred from an employee to another employee or workgroups (Nonaka & Takeuchi, 1995). In another study, Huang, Kristal, and Schroeder (2008) postulate that internal learning generates knowledge within the organization through training and employees' suggestions, while customers and suppliers are identified as important sources of external knowledge. The processes of internal and external learning are meta-routines that emphasize problem solving and collaboration (Huang et al., 2008). The intentions to learn, share, and transform information within the organization and through external stakeholders promote the needs to collaborate. Thus:

Proposition 4: Internal-external learning influences collaborative networks

Perceived Effectiveness

Soller and Lesgold (2000) posit that it would be impossible to enumerate and evaluate the effectiveness of all possible interactions from collaboration because the dynamic nature of human communication and interaction involves too many variables. Researchers are able to measure the perceived effectiveness and impact of knowledge transfer and collaborative technology. While intention is immeasurable, it does nonetheless influence the perception and motivation to collaborate. Similarly, Stonebraker and Hazeltine (2004) examined the effectiveness of a virtual learning program managed by a multinationals company (MNC) and found that familiarity with the technology is directly associated with satisfaction of virtual learning and positive perception of course relevance to the job. Therefore, it is proposed that:

Proposition 5: Perceived effectiveness influences collaborative networks

Perceived Usefulness

Perceived usefulness reflects an employee's belief in the ability of collaborative networks to obtain information and services, to share experiences with others, and to enhance the performance of information exchange. In a study of virtual communities, Lin (2007) examined the impact of online information quality, system quality, and service quality on the sustainability of collaborative networks, using the technology acceptance model (TAM) as a theoretical framework. The information from collaborative networks is useful only if it is accurate, informative, and updated (Perkowitz & Etzioni, 1999). Reliable information quality improves the perceived usefulness of collaborative networks by enhancing the fit between network content and employees' information requirements (Lin, 2007), which in turn impacts the use of collaborative networks.

Proposition 6: Perceived usefulness influences collaborative networks

Research Method

To gather quantitative data needed for testing the proposed conceptual model, a questionnaire survey was conducted. The survey was both administered online as a Qualtrics web site and distributed in hard copies by mailing, and the survey scope was limited to the manufacturing industries in Malaysia.

Instrument Design and Pilot Testing

An initial list of survey items (questions) was derived from past research in the areas of cooperative learning, collaborative learning, and workplace learning. Using an ethnographic approach, the list was then expanded based upon the researchers' past experience and knowledge of collaborative networks, and a series of questions addressing the dimensions and key variables of the study were developed. The resulting questionnaire was pilot tested by colleagues and academic staff in the university that one of the authors is affiliated with. Consequently, some questions were reworded in order to increase the clarity of questions, and to improve the validity and reliability of the survey instrument. Content validity and construct validity were both determined using exploratory analysis. The final version of the questionnaire consisted of 44 questions organized into three main sections: type of manufacturing organizations, experience with collaborative networks, and number of hours using collaborative networks, plus demographics.

Survey Implementation

For online administering, the questionnaire was implemented as a Qualtrics web-based survey. Compared to conventional mail surveys, the cost of Qualtrics web-based surveys for sending questionnaires and coding data is relatively low, and has a short turnaround time. Potential errors due to data transfer and codification are eliminated (Nardi, 2006). The Qualtrics also provides the benefit of generating an electronic dataset of responses pre-coded in SPSS format.

The snowball sampling method was employed to identify and recruit survey research subjects from various manufacturing organizations. A total of 61 individuals were invited to complete the online survey, of which 44 chose to participate. In addition, 400 copies of the questionnaire were sent via postal mail, and 248 copies were returned. Altogether, 292 responses were collected, yielding an overall response rate of 63%. Two responses were found invalid, leaving 246 responses (84%) usable.

Participants were requested to answer all questions. The data were collected over a seven-month period.

Sample Population

Over half of the participants (52.0%, n=128) were in the age range of 30-39, followed by 35.0% (n=86) in the age range of 20-29. The majority of participants (58.9%, n=145) possessed at least a diploma or a bachelor degree. The participants came from MNCs (72%, n=177) and SMEs (28%, n=69). On the other hand, 26.8% (n=66) of the participants were from Production/Operations/ Manufacturing/Assembly, followed by 19.9% (n=49) from Technical/Engineering.

Analyses and Results

Test for Normality

Preliminary analysis was conducted to generate descriptive statistics and to examine the normality of data, missing data, and multicollinearity. There was no need for treatment of missing data or value since participants in both the online and paper surveys answered all questions in the questionnaire. Normality is the most fundamental assumption in statistical analysis which could influence the validity of the results. Thirty five items were tested (see Table 1).

Table 1: Skewness and kurtosis (n= 246)

	skewness	kurtosis
B1 Access to a computer workstation to perform job	-2.36	5.14
B2 Access to networked computer/email for work	-2.13	4.04
B3 Access to learning through computer network	-1.30	0.94
B4 Access to on-line shared databases to facilitate work	-1.26	0.51
B5 Support from supervisor/manager to collaborate	-1.27	1.79
C1 Job requires to work in teams	-1.45	1.48
C2 Job requires to teleconference with other sites	-0.43	-1.27
C3 Job requires to share ideas, work and information	-1.18	0.36
C4 Job can only be completed if other members complete theirs	-0.56	-0.80
C5 Performance depends on the results of the team	-0.77	-0.31
D1 Frequently share ideas, work and information	-1.10	0.33
D2 Frequently interact online with peers/team	-0.80	-0.53
D3 Easily obtained help and support on-line	-0.77	-0.52
D4 Frequently share on-line meetings	-0.50	-1.06
D5 Team helps each other to learn	-1.12	0.63
E1 Learn from shared information from the network	-0.91	-0.07
E2 Receive training to collaborate effectively	-0.78	-0.27
E3 Participate in improvement projects	-.988	0.39
E4 Learn from external parties	-.215	-1.21
E5 Learn from peers/team	-1.29	1.25
F1 Work efficiently through use of information from the network	-1.00	-0.01
F2 Work interdependently using the computer network	-0.94	0.01
F3 Use computer to share information effectively	-1.18	0.54
F4 Team achieves goals using information from the network	-0.84	-0.26
F5 Team produces good quality collaborative work	-0.96	0.09
G1 The network system/tool is useful	-1.21	0.78
G2 The shared database is useful	-1.21	0.92
G3 The on-line meetings with external parties are useful	-0.66	-0.67
G4 The network system is useful for sharing information	-1.17	0.51
G5 The on-line learning system is useful	-0.75	-0.17
H1 Online knowledge and information	-0.88	-0.04
H2 Work using online system/network	-1.14	0.43
H3 Share and exchange information	-0.99	0.09
H4 Participate in e-learning	-0.09	-1.21
H5 Participate in workgroup activities	-0.62	-0.58

Note: Standard error for skewness = 0.16; standard error for kurtosis = 0.31

All items showed normality ranging between -0.43 to -2.36 for skewness (level < 3.0) and ±0.01 to 5.14 (level < 10.0) for kurtosis. The data demonstrated normal distribution.

Outliers can result in non-normality data and affect the validity of the statistical analysis (Hair et al., 2006). Outliers that are not too extreme are retained and care was taken not to recode the value, in order to maintain the integrity of the study. The researchers verified outlier items to ensure correct data entry or data coding, and found no anomaly.

Bartlett's test of sphericity and the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy were also carried out. The KMO value >0.5, indicated appropriateness and fulfilling of the required sampling adequacy (Field, 2005; Hair et al., 2006; Kaiser, 1974). According to Hutchenson and Sofroniou (1999, as cited in Field, 2005), values between 0.5 and 0.7 are mediocre, values 0.7 to 0.8 are good, values between 0.8 and 0.9 are great, and values above 0.9 are superb. In this study, the KMO values for 33 items were in the upper range, between 0.80 and 0.89 as shown in Table 2, which is considered as great.

Table 2: Kaiser-Meyer-Olkin and Barlett's test

Factors	Measure of Sampling Adequacy	Test of Sphericity		
		Approx. Chi-Square	d.f.	Sig.
Organizational Support	0.85	1206.82	10	0.000
Positive Interdependence	0.84	682.62	6	0.000
Promotive Interactions	0.85	1088.88	10	0.000
Internal-External Learning	0.80	619.35	6	0.000
Perceived Effectiveness	0.87	1493.24	10	0.000
Perceived Usefulness	0.89	1177.02	10	0.000
Collaborative Networked Learning	0.89	1065.80	10	0.000

The Bartlett test of sphericity determines the overall significance of all correlations within the correlation matrix (Hair et al., 2006), and these were found to be significant ($p<0.001$).

Assessment of Unidimensionality

Unidimensionality is a prerequisite for validity and reliability (Cortina, 1993; Gerbing & Anderson, 1988). A measure's dimensionality is concerned with the homogeneity of items (Netemeyer et al., 2003, p. 9). Netemeyer et al. further define a measure as unidimensional when it has "statistical properties demonstrating that its items underlie a single construct or factor" (p. 9). Unidimensionality indicates that all items of the scale are measuring a single underlying factor or construct (Field, 2005). Using exploratory factor analysis (EFA), the unidimensionality test provides evidence of a single latent construct (Flynn et al., 1990).

Using the Eigenvalue >1.0 rule, any construct with more than a single factor should be segregated or the items should be removed. All constructs rotated with only a single factor, and therefore they were unidimensional. The scree plots (see Figure 3) showed the Eigenvalues against the number of factors.

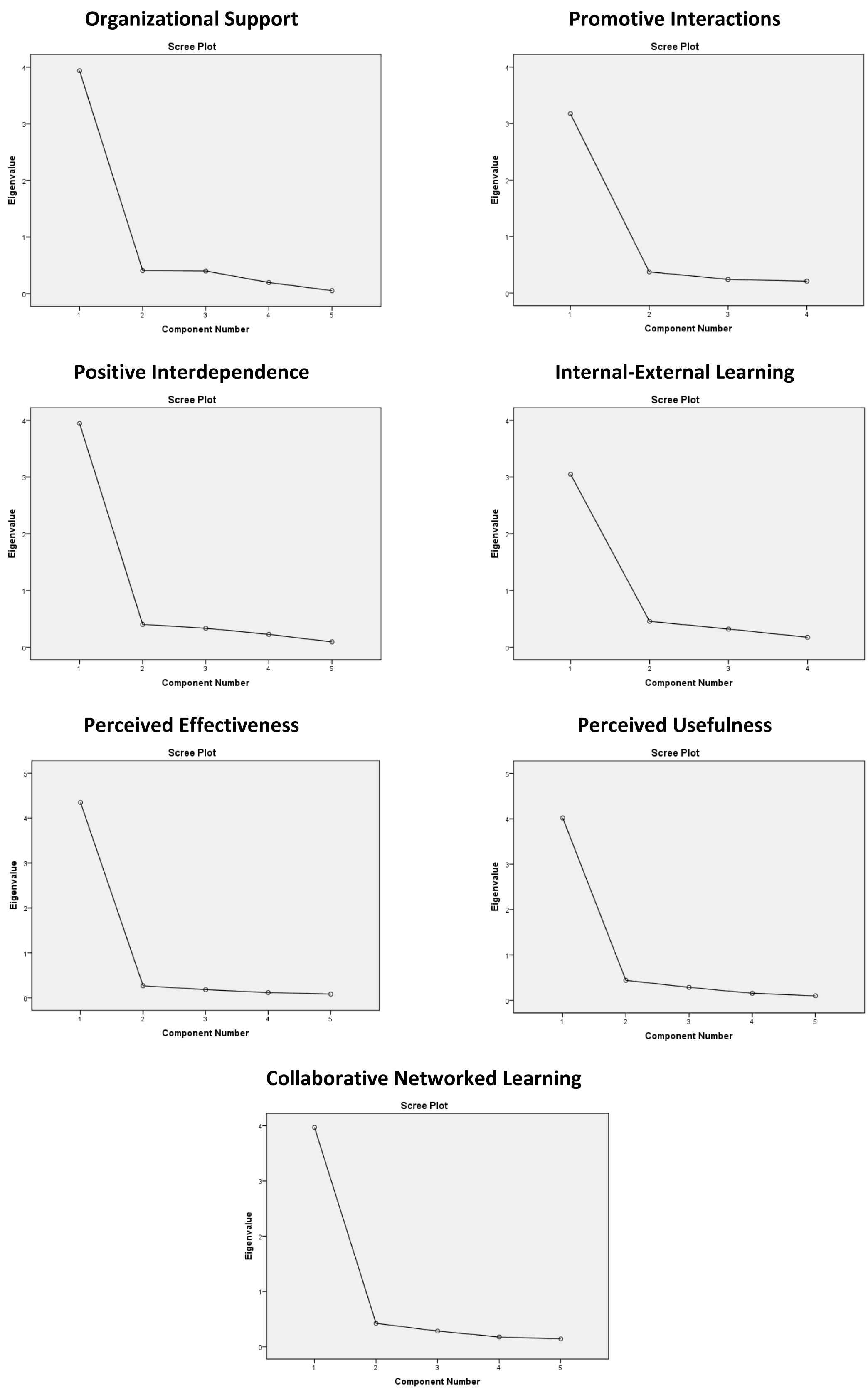

Figure 3: Scree plots after items purification

Validity of Measurement

The construct validity assessment involves examining the convergent and divergent validity of the scale items to ensure that the construct variables yield good fit to the quantitative survey data. Construct validity determines how well the instrument measures or can measure the underlying constructs (Black, 2005; Campbell & Fiske, 1959; Cooper & Schindler, 1998; Cronbach & Meehl, 1955; Netemeyer et al., 2003). The study deduced propositions from the literature and theories that are relevant to the concept of CNL. Factor loading >0.4 is considered significant for convergent and divergent validity (Hair et al., 1998). All items had a factor loading ranging from 0.80 to 0.95 (>0.4), and fulfilled the requirement for convergent and divergent validity.

Reliability

For reliability test, the study uses Cronbach alpha. The alpha values were within the range from 0.90 to 0.96 (Table 3). As this was >0.7, they were considered reliable. The closer the correlation coefficient is to 1.0, the more reliable it is (Nardi, 2006, p. 63).

Table 3: Reliability Test - Cronbach's Alpha

Constructs	Cronbach's Alpha	N of Items
Organizational Support (B)	0.90	4
Positive Interdependence (C)	0.91	4
Promotive Interactions (D)	0.93	5
Internal-External Learning (E)	0.90	4
Perceived Effectiveness (F)	0.96	5
Perceived Usefulness (G)	0.94	5
Collaborative Networked Learning (H)	0.93	5

Factor Analysis

Exploratory factor analysis (EFA) is used for establishing instrument validity (Black, 2005; Flynn et al., 1990). EFA is also used in item reduction to identify a small number of factors that explain most of the observed variance in the manifest variables (Field, 2005). In factor analysis, the principle component for data extraction helps to create compound measures by integrating several items (Hair et al., 2006) and explain variance and covariation among the measures (Green et al., 2000). The result of EFA is given in Table 4.

Table 4: Result of Factor Analysis

Items (grouped by construct)	Component	Eigenvalue	% Variance	Chi-square
B1 Access to a computer workstation to perform job	0.94	3.94	78.75	1206.82
B2 Access to networked computer/email for work	0.94			
B3 Access to learning through computer network	0.92			
B4 Access to on-line shared databases to facilitate work	0.82			
B5 Support from supervisor/manager to collaborate	0.82			
C3 Job requires to share ideas, work and information	0.91	3.17	79.36	682.62
C5 Performance depends on the results of team	0.92			
C1 Job requires to work in teams	0.87			
C4 Job can only be completed if other members complete theirs	0.87			
D2 Frequently interact online with peers/team	0.93	3.94	78.89	1088.88
D3 Easily obtained help and support on-line	0.93			
D1 Frequently share ideas, work and information	0.89			
D4 Frequently share on-line meetings	0.85			
D5 Team help each other to learn	0.84			

Items (grouped by construct)	Component	Eigenvalue	% Variance	Chi-square
E1 Learn from shared information from the network	0.91	3.05	76.20	619.35
E2 Receive training to collaborate effectively	0.89			
E5 Learn from peers/team	0.87			
E3 Participate in improvement projects	0.83			
F4 Team achieves goals using information from the network	0.95	4.35	86.93	1493.24
F2 Work interdependently using the computer network	0.94			
F3 Use computers to share information effectively	0.93			
F1 Work efficiently through use of information from the network	0.92			
F5 Team produces good quality collaborative work	0.92			
G2 The shared database is useful	0.94	4.02	80.39	1177.02
G4 The network system is useful for sharing information	0.93			
G1 The network systems/tool is useful	0.93			
G5 The on-line learning system is useful	0.88			
G3 The on-line meetings with external parties are useful	0.80			
H3 Share and exchange information	0.92	3.97	79.36	1065.80
H1 Online knowledge and information	0.92			
H2 Work using computer system/network	0.91			
H5 Participate in work groups	0.87			
H4 Participate in e-learning	0.84			

All measurement items had factor loadings between 0.80 and 0.95, exceeding the minimum value of 0.60 (Nunnally & Bernstein, 1994), and all were found significant ($p<0.001$).

Discussion and Conclusion

The study clearly demonstrates that the majority of the respondents in manufacturing organizations are provided with infrastructure and applications to collaborate and share information. Although the result implies that employees in manufacturing organizations are expected to work in teams, it is premature to conclude that all employees use networks to collaborate. The study depicts the factors that would influence the use of collaborative networks, provided that all necessary systems and applications are available to support sharing information and using the network to learn.

The study further extended the empirical research into collaborative networks in the context of manufacturing environment. All the propositions (P1, P2, P3, P4, P5, and P6) are supported. In other words, the six factors (organizational support, promotive interactions, positive interdependence, internal-external learning, perceived effectiveness, and perceived usefulness) were found to be significant in influencing the use of collaborative networks in manufacturing.

Organizational Support

The study shows that organization support is important in determining the use of technology as a mediator to collaborate. The study also confirms the findings from other studies that employees are self-directed and that manufacturing organizations are willing to support their employees' learning and engagement with others in the learning networks (Fuller et al., 2007; Smith, 2003) and to provide extrinsic motivation to use technology (Scott et al., 2009). With access to a computer network, employees are able to communicate and collaborate with others. The network provides access to global databases, to learn, and to share information. Other studies recommend a supportive organizational context and supportive interpersonal climate, as well as the positive effects of facilitative leadership (Edmondson et al., 2001; Sarin & McDermott, 2003) to promote collaborative works.

Positive Interdependence

The study supports the findings that it requires positive interdependence for self-managing teams, virtual global teams, and other cross-functional teams to succeed in supporting joint improvement activities and new product development (Grant et al., 2004) . It is coherent with the findings from Giuliani (2007) and Lechner et al. (2006) that interdependencies may shift from communication networks to collaborative networks while working on joint technology innovation/development projects with customers, suppliers, and partners (Giuliani, 2007; Lechner et al., 2006). While Lusch, Vargo, and Tanniru (2010) acknowledge that support from the organizations is important, they also emphasize the needs to foster employee participation in a complex manufacturing network. Employees' positive dependencies focus on shared tasks and the need to work collaboratively to accomplish deliverables set forth by the organization. Clearly, the result demonstrates that employees at jobs that require them to work in teams or to share ideas, work, and information are more likely to develop collaborative networks.

Promotive Interactions

Although interactions with computer-supported social networks (Wellman et al., 2000) are considered as strongly interactive, Kreijns et al. (2003) argue that interactions between the workgroup members will not automatically occur just because the technology allows for social interaction. However, the study shows that frequent interactions with virtual team members help to support learning. The interactions could be within the enterprise as well as with partners from external organizations. Collaboration increases interconnections between organizations (Provan & Milward, 1995), increases interactions (Chen, 2011), and fosters learning among employees (Inaba et al., 2000). Employees who frequently interact with peers or teams are more comfortable in working in teams and engaging in collaborative networks.

Internal-External Learning

The study also indicates that employees learn to obtain information shared on the computer network and through collaborative efforts with their teams. The ability to learn from peers and teams through the computer network motivates employees to continue using the systems or networks. The study further support the findings that learning experience motivates more employees to participate in the collaborative network (Gebauer et al., 2012).

Perceived Effectiveness

Stonebraker and Hazeltine (2004) found that familiarity with the technology is directly associated with virtual learning satisfaction and positive perception of course relevance to the job. Similar to Murgolo-Poore et al. (2003), this study also found a relationship between perceived effectiveness and the decision to use the network. The frequency at which employees access information online is influenced by employees' perception about the network's ability to provide information for them to work efficiently. Likewise, for employees to work online using a collaborative network, the system has to be effective in sharing real-time information. For the online sharing and exchange of information to take place, they need to believe that the information to be obtained from the network will help them to produce high quality collaborative work.

Perceived Usefulness

Like perceived effectiveness, the construct of perceived usefulness was borrowed from the technology acceptance model (TAM) as a factor influencing the use of collaborative networks. The technology acceptance model (TAM) is theoretically grounded, well documented in the literature, and widely accepted and used to explain the acceptance of technology (Davis, 1986, 1989;

Venkatesh et al., 2003). System reliability, convenience of access, response time, and flexibility are qualities valued by users, and they affect the perceived usefulness (DeLone & McLean, 2003; Nelson et al., 2005). While Lin and Lu (2000) argue that information quality is a valuable predictor of the perceived usefulness, the study shows that perceived usefulness is indicative of collaborative network use. Employees expect the online learning systems and other network applications to be useful in order for collaborations to be effective. Likewise, to collaborate in virtual teams and share information online, the content has to be perceived as being useful.

Research Limitation

Several studies postulate that the quality of online information may affect the sustainability of a system (Ahn et al., 2004; Cao et al., 2005; DeLone et al., 2003; Lin, 2007; Rodgers et al., 2005). Participants' opinion about collaborative networks may have influenced by the quality of information at the time. However, the sustainability of a system can be better understood if a second survey is conducted after an interval. As the study was limited to the Malaysia manufacturing environment, the findings cannot be generalized to other contexts, but they may be referential and indicative beyond Malaysia nevertheless.

Contribution of the Research

This study contributes towards the determination of influential factors in collaborative networks in the context of manufacturing. Prior studies of collaborative learning merely mirrored the use of computer mediated learning, particularly among participants in learning institutions or with the focus on a population of students. The survey instrument complements the technology acceptance model (TAM). The study expands the TAM model to include organizational support, interdependence, interactions, and internal-external learning as factors clearly having a direct influence on employees' adoption of and engagement in collaborative networks in the manufacturing sector.

Further Research

The opportunity for employees to learn in a workplace is not just limited to attending training programs, but also includes participating in work-related activities (Billet, 2001, 2004; Fuller et al., 2004; Keating, 2006). In the past, where boundaries between jobs were the basis for job classifications, collaborative networks tend to remove these boundaries and undermine the system of training entitlements for employees. Further research could focus on building trust and relationship among employees engaging in collaborative networks. Investigation on the frequency, intensity, and centricity of interaction influenced by collaborative networked learning would provide better understanding of how employees develop learning goals and engage with others in learning networks.

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