Process Construct in the Virtual R&D Teams

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Abstract: literature proves the importance of the process role in the effectiveness of virtual research and development (R&D) teams for new product development (NPD). However, the factors that make process construct in a virtual R&D team are still unclear. The manager of virtual R&D teams for NPD does not know which items of process should be used. To address the gap and answer the question, the study presents a set of factors that make a process construct. The proposed construct modified by finding of the field survey. We empirically examine the relationship between construct, dimensions and its factors by employing the Structural Equation Modeling (SEM). A measurement model built based on the 13 preliminary factors that extracted from the literature review. The result shows 9 factors out of 13 factors maintaining to make process construct. These factors can be grouped into two dimensions namely generating report and collaborative system. The findings can help new product development managers of enterprises to concentrate on the main factors for leading an effective virtual R&D team. In addition, it provides a guideline for future research.

Key words: Collaboration teams, questionnaires performance, cross-functional teams, product development, measurement model, virtual team

1. INTRODUCTION

A virtual team is defined as "a small temporary group of geographically, organizationally and/or time dispersed knowledge workers who coordinate their work, mainly with electronic information and communication technologies to carry out one or more organization tasks" (Ale Ebrahim et al., 2009b). The virtual R&D team is a form of a virtual team, which includes the features of virtual teams and concentrates on R&D activities (Ale Ebrahim et al., 2011). "We are becoming more virtual all the time!" is heard in many global corporations today (Chudoba et al., 2005). On the other hand, new product development (NPD) is widely recognized as a key to corporate prosperity (Lam et al., 2007). The specialized skills and talents needed for developing new products often remain locally in pockets of excellence around the company. Therefore, enterprises, have no choice but to disperse their new product development units to gain access into such dispersed knowledge and skills (Kratzer et al., 2005). As a result, enterprises are finding that internal development of all technologies needed for new products and processes are difficult or impossible. They must increasingly receive technology from external sources (Stock and

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Tatikonda, 2004).

Virtualization in NPD has recently begun to make a serious headway due to the rapid growth of a large variety of technologies. This means that virtuality in NPD is now technically possible (Leenders et al., 2003). Due to increasing and changing product features, generally product development has become more complex, with increasing complexity in the supply chain. Therefore, more close collaboration between customers, developers, and suppliers has become vital. The foretold collaborations often involve individuals from different geographical locations that could now be brought together by using the various types of information technology. Although the process of new product development in virtual teams for many purposes has received notable attention in the literature, little has been said about collaborative tools and effective virtual teams for NPD (Ale Ebrahim et al., 2009a). In addition, the literature did not reveal an adequate focus on the factors which can construct a process role for a virtual R&D team for NPD.

This paper is structured as follows. Firstly, based on prior research, we extracted the 13 factors of process construct in the virtual R&D teams. Next, Structural Equation Modeling (SEM) was used as an analytical tool for testing the estimations and testing the process construct measurement models. Then, we adjusted the preliminary process construct model by fitting the model according to the SEM fitness indices and made a final measurement model. The paper infers with a discussion and future guidelines.

2.   PROCESS ROLE IN THE LITERATURE

The company's processes need to be re-aligned with the capabilities of virtual teams as opposed to face-to-face teams. This involves an understanding of the virtual team and existing processes (Bal and Gundry, 1999). However, the key elements in knowledge sharing are not only the hardware and software, but also the ability and willingness of team members to actively participate in the knowledge sharing process (Rosen et al., 2007). Proximity enables team members to engage in informal work (Furst et al., 2004). Virtual team members are more likely to treat one another formally, and less likely to reciprocate requests from one another (Wong and Burton, 2000). Shin (2005) argued that the lack of physical interactions and informal relationships decrease the cohesiveness of virtual teams. Formal practices and routines designed to formally structure tasks were reported to lead to higher quality output of virtual team (Massey et al., 2003). The physical absence of a formal leader exacerbates the lack of extrinsic motivation (Kayworth and Leidner, 2002). In virtual teams which rarely meet face-to-face, team leaders often have no choice but to implement a formal team structure. Synchronous written documents helped virtual teams to overcome challenges associated with spoken language, and this enabled teams to overcome challenges associated with asynchronous and lean written communication (Shachaf, 2008).

Kirkman, et al. (2004) demonstrated a positive correlation between empowerment and virtual team performance. High performance teams are distinguished by a passionate dedication to goals, identifying and emotional bonding among team members, and a balance between unity and respect for individual differences.

Virtual team members must have clear roles and accountabilities. Lack of visibility may cause virtual team members to feel less accountable for results, and therefore, explicit facilitation of teamwork takes on heightened importance for virtual teams. Temporal coordination mechanisms such as scheduling deadlines and coordinating the pace of effort are recommended to increase vigilance and accountability (Massey et al., 2003).

From the process point of view, the items which are required for effective virtual teams are ambiguous. The researcher extracted 13 items related to the process construct based on reviewed papers (Table 1).

3.   RESEARCH METHODOLOGY AND DATA COLLECTION

To build a measurement model of process construct in virtual R&D teams for new product development, we conducted a Web-based survey mainly in Malaysian and Iranian manufacturing enterprises, in a random sample of small and medium enterprises. Web-based survey method was selected because it is a cost-effective and quick method to obtain feedbacks from the beliefs of the respondents. The rapid expansion of Internet users has given Web-based surveys the potential to become a powerful tool in survey research (Sills and Song, 2002, Ebrahim et al., 2010). A Likert scale from one to five was used. This setup provided the respondents with a series of attitude dimensions. For each factor, the respondents were asked whether the factor is unimportant or extremely important using a Likert scale rating. The questionnaires were e-mailed to the managing director, R&D manager, new product development manager, project and design manager and appropriate personnel who were most familiar with the R&D activities within the firm.

Invitation e-mails was sent to each respondent, reaching 972 valid email accounts, with reminders following every two weeks up to three months. 240 enterprises completed the questionnaire, for an overall response rate of 24.7% (Table 2).

Table 1 Items related to the process construct in virtual teams

Factor name	Factor descriptions	References
Proc1	Project control (such as Intranet-based project status tracking system)	(Leenders et al., 2003, Cascio and Shurygailo, 2003)
Proc2	Project reporting system (such as MS Project reporting system)	(Leenders et al., 2003)
Proc3	Doing business together	(Jain and Sobek, 2006)
Proc4	Reduce travelling time and cost	(Hardin et al., 2007, Fuller et al., 2006, Bergiel et al., 2008, Cascio, 2000)
Proc5	Reduce the number of working hours need to solve the task	(Johnson et al., 2001, Precup et al., 2006, Gassmann and Von Zedtwitz, 2003)
Proc6	Collaborative solutions	(Coleman and Levine, 2008, Thissen et al., 2007)
Proc7	Facilitates data collection in NPD project	(Leenders et al., 2003)
Proc8	Interact with customers for gathering new product features	(Andersen and Drejer, 2009, Daoudi, 2010)
Proc9	Provide quantity answer	(Zemliansky and Amant, 2008)
Proc10	Generate an easy interpretable answer	(Zemliansky and Amant, 2008, Corso et al., 2006)
Proc11	Ease of generating reports	(Kirkman et al., 2002)
Proc12	Ease of data entry	(Zemliansky and Amant, 2008, Thissen et al., 2007, Corso et al., 2006)
Proc13	Ability to accommodate multiple users	(Kratzer et al., 2005, Cascio, 2000, Gaudes et al., 2007)

Table 2 Summary of online survey data collection

Numbers of emails sent to enterprises	3625
Total responses (Clicked the online web page)	972
Total responses / received questionnaire (%)	26.8
Total completed	240
Total completed / received questionnaire (%)	24.7

4. ANALYSIS AND RESULTS

Gerbing and Anderson (1988) suggested using confirmatory factor analysis (CFA) for scale development because it affords stricter interpretation of uni-dimensionality than what is provided by traditional approaches such as coefficient alpha, item-total correlations, and exploratory factor analysis. The evidence that the measures were uni-dimensional, whereby a set of indicators (factors) shares only a single underlying construct, was assessed using CFA (Anderson and Gerbing, 1988). According to Anderson and Gerbing (1988), after data collection, the measures' purification procedures should be used to assess their reliability, uni-dimensionality, discriminant validity, and convergent validity. For reliability analysis, Cronbach's alpha was employed to each factor. From Table 3, all items with Cronbach's α greater than the threshold value of 0.6 were included in the analysis and the rest were omitted from analysis. Hence, the factors Tech1, Tech10, Tech11 and Tech13 were excluded from further analysis. In general, the reliability of the contents in the questionnaire exhibits good reliability across the samples.

Structural Equation Modeling (SEM) using AMOS 18 was employed for validating the measurement model. The statistical analysis was estimated simultaneously for both measurement and structural models (Dibrell et al., 2008). In order to ensure that the factors made the right construct, the measurement model was examined for its fit. Given this, the model was assessed for convergent and discriminant validity.

Convergent validity was established using a calculation of the factor loading, average variance extracted (AVE) and composite reliability (CR). The factors which have standardized loadings exceeding 0.50, were retained (Dibrell et al., 2008).

Factor analysis on 13 process construct items reduced them into two dimensions (Table 4). The first dimension includes Proc5, Proc8, Proc9, Proc10, Proc11, Proc12 and Proc13 was named "Generate report (GR)", and the second dimension consists of Proc1, Proc2, Proc3, Proc4, Proc6 and Proc7 was named "Collaborative solutions (CS)".

The measurement model had adequate convergent validity since the calculated CR and AVE values were 0.953 and 0.612, respectively. The squared multiple correlations between two variables were determined and checked with the relevant AVE. All correlations were within the acceptable range.

Table 3 Virtual team process items reliability analysis and standardized regression weights (factor loadings)

Factor name	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted	Standardized Factor Load
Proc1	.668	.937	.726
Proc2	.682	.936	.746
Proc3	.708	.935	.781
Proc4	.717	.935	.730
Proc5	.726	.935	.710
Proc6	.713	.935	.763
Proc7	.817	.932	.867
Proc8	.786	.933	.807
Proc9	.704	.935	.746
Proc10	.667	.937	.693
Proc11	.754	.934	.866
Proc12	.742	.934	.850
Proc13	.630	.938	.684

Table 4 Rotated Component Matrix[a] of virtual team process construct items

Factor name	Raw Component		Rescaled Component	
	1	2	1	2
Proc11	.777	.282	.815	.295
Proc12	.704	.266	.792	.299
Proc13	.772	.194	.767	.193
Proc9	.657	.271	.737	.304
Proc8	.599	.445	.663	.492
Proc10	.609	.329	.650	.351
Proc5	.571	.520	.575	.524
Proc2	.219	.823	.222	.836
Proc3	.269	.749	.287	.798
Proc1	.281	.828	.266	.784
Proc7	.520	.623	.551	.659
Proc6	.408	.590	.441	.638
Proc4	.545	.550	.542	.546

Extraction Method: Principal Component Analysis. Rotation Method:
Varimax with Kaiser Normalization.
a. Rotation converged in 3 iterations.

For model fitting, AMOS for model version 1 (Figure 1) was used, and there was a lack of model fit, whereby RMSEA = 0.164, GFI = 0.751 and CFI = 0.823. Based on MI, Proc1, Proc5, Proc12 and Proc13 were dropped. From the MI, Proc1 equals to Proc2, Proc11 equals to Proc12 and Proc3 equals to Proc13. Therefore, the remaining items

represent some of the dropped items. Items which had a lower factor load for any equality cases were omitted. With this modification, the final measurement model was developed (Figure 2) and the model was well fitted (CMIN/DF = 1.905, GFI = 0.920, RMR = 0.035, NFI = 0.932, CFI = 0.966, IFI = 0.966 and RMSEA = 0.085). The factor loading in the final virtual team benefit measurement model was above 0.74, which was quite significant.
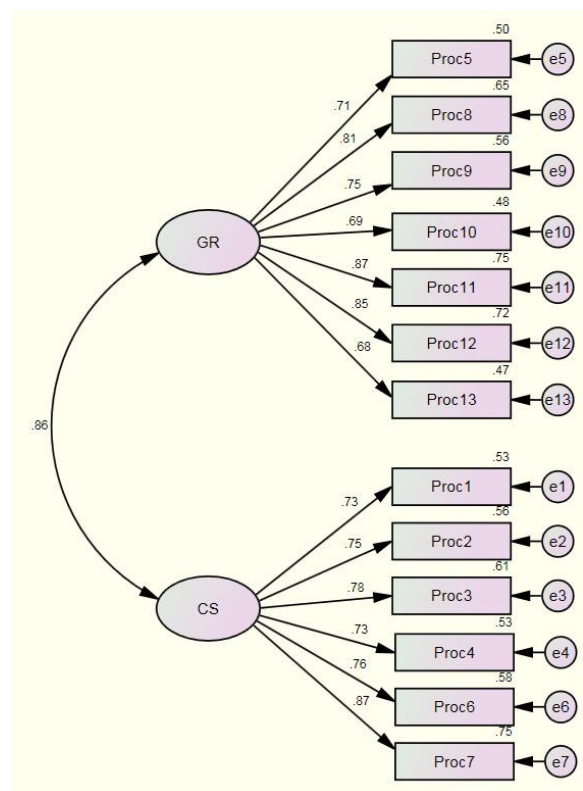

Figure 1 Virtual team process measurement model version1 with standardized factor loading

5. DISCUSSION ON VERIFIED MODEL

The final measurement was carried out based on measurement model version1 by classifying the factors into two groups according to their relevant factor loading with a threshold value of 0.546. Data purification did not discard any items since all items' alpha values were greater than 0.6. While fitting the virtual team process construct measurement model, the items Proc1 (Project control (such as Intranet-based project status tracking system)), Proc5 (Reduces the number of working hours need to solve the task), Proc12 (Ease of data entry) and Proc13 (Ability to accommodate multiple users) were dropped. Most of the

discarded items had equality with the remaining items, and the ones which had a less factor load were deleted. Modification indices (MI) based on regression weights shows that Proc1 equals to Proc2, Proc11 equals to Proc12 and Proc13 equals to Proc3. Therefore, in future research, similar items can be deleted from the questionnaires.

The results for the final measurement model of process construct in virtual R&D teams show the share of two dimensions that are strongly correlated to each other. The first dimension includes Proc8, Proc9, Proc10 and Proc11 was named "Generate report (GR)" whereas the second dimension consists of Proc2, Proc3, Proc4, Proc6 and Proc7 was named "Collaborative solutions (CS)" (Table 5). Therefore, the two dimensions that make up the process constructs in virtual R&D teams should be taken into account by NPD Manager to have an effective team.

6. CONCLUSIONS

This research explores the 13 factors related to NPD process in a virtual team environment and extract two dimensions with nine factors. However, the factors which mainly contribute to the process construct in virtual R&D teams' for new product development were unknown in the preceding literature. The findings of this study will contribute some knowledge in the literature and build a foundation for further understanding of the process elements in virtual R&D teams for new product development. The measurement model shows two dimensions ("Generate report" and "Collaborative solutions") with nine factors that made the process constructs. These dimensions and factors can be sorted by their factor loading, which reflects the factor's weight. Therefore, the managers of NPD are able to provide a better platform for virtual teams by concentrating on the two dimensions and their main relevant nine factors.

Future research is needed to examine the effects of each factor to perform the virtual R&D teams whereas the other constructs of virtual teams such as people and technology are taken into account. A new SEM is needed to demonstrate the relationships between factors-construct and construct-construct, which are not yet investigated.
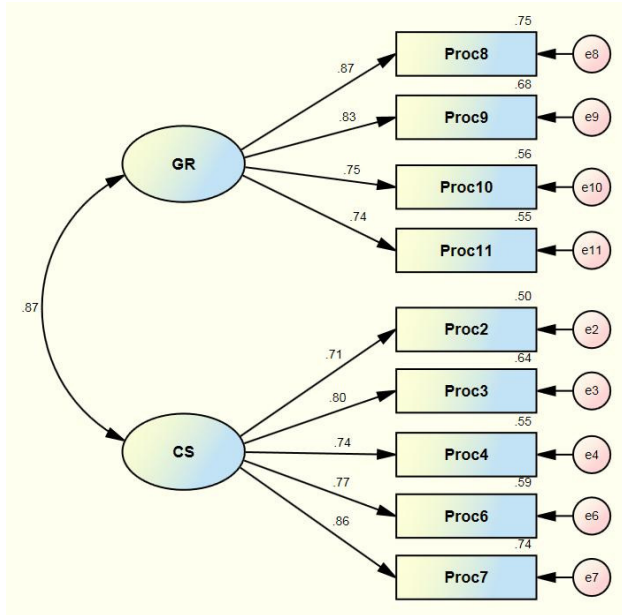

Figure 2 Final virtual team process measurement model with standardized factor loading

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Table 5 Two dimensions of virtual team process construct

Dimensions	Factor name	Main items	Equal items
Generate report (GR)	Proc8	Interact with customers for gathering new product features	
	Proc9	Provide quantity answer	
	Proc10	Generate an easy interpretable answer	
	Proc11	Ease of generating reports	Proc12 - Ease of data entry
Collaborative solutions (CS)	Proc2	Project reporting system	Proc1 - Project control
	Proc3	Doing business together	Proc13 - Ability to accommodate multiple users
	Proc4	Reduce travelling time and cost	
	Proc6	Collaborative solutions	
	Proc7	Facilitates data collection in new product development project	

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