Proceedings of the
International Conference on Mechanical Engineering and Renewable Energy 2011
(ICMERE2011) 22- 24 December 2011, Chittagong, Bangladesh

ICMERE2011- PI-204

KNOWLEDGE WORKER ROLE IN THE VIRTUAL R&D TEAMS FOR NEW PRODUCT DEVELOPMENT: A MEASUREMENT MODEL

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Abstract- *Knowledge workers (KW) play an important role in the effectiveness of virtual R&D teams for new product development. A large amount of KW literature focuses at the individual level and less attention paid on virtual R&D teams with dispersed knowledge workers. From KW point of view, the factors that required for effective virtual teams are unclear. To address this gap, base on the literature review, the paper presents a set of factors that make the preliminary knowledge workers construct with 11 factors. The proposed construct modified by finding of the field survey (N = 240). We empirically examine the relationship between construct and its factors by employing the structural equation modeling (SEM). The result shows 5 factors out of 11 preliminary factors maintaining to make KW construct. The finding can help new product development managers of enterprises to concentrate in the main factors for leading an effective virtual R&D team. In addition, it provides a guideline for software developer to implement the KW perceptions in the collaborative tools.*

Keywords: Collaboration; Questionnaires; Cross-Functional teams; Product development; Structural equation modeling

1. INTRODUCTION

Knowledge workers in virtual teams require substantial communication with colleagues and supervisors to perform their work activities [1]. Nowadays, a virtual team is able to create the ability for individuals, including knowledge workers, to work anytime and anywhere through computer networks and reduces the need for teams to be collocated [2-3]. Knowledge workers in virtual teams need to facilitate better communication among team members in order to perform the task. Virtual teams have altered the expectations and boundaries of knowledge workers' interactions and made a new opportunity to develop a business [4]. Virtual teams are defined as "small temporary groups 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 organizational tasks" [5]. Virtual R&D team is a form of a virtual team, which includes the features of virtual teams and concentrates on R&D activities [6]. "We are becoming more virtual over the time!" is heard in many global corporations today [7]. On the other hand, new product development (NPD) is widely recognized as a key to corporate prosperity [8]. The specialized skills and talents required for the development of new products often reside (and develop) locally in pockets of excellence around the company or even around the world. Firms, therefore, have no choice but to disperse their new product units to access such dispersed knowledge and skills [9]. Virtualization in NPD has recently started to make serious headway due to developments in technology - virtuality in NPD which is now technically possible [10]. As product development becomes more complex, knowledge workers also have to collaborate more closely than in the past. These kinds of collaborations almost always involve individuals from different locations, so virtual team working supported by information technology (IT), offers notable potential benefits [11].

The literature on team effectiveness usually discusses collocated teams and few studies have been performed on effectiveness and performance of the distributed teams [12]. The current literature on KW in virtual teams is mainly focusing on the individual level of a knowledge worker. However, factors that make KW

construct and influence the effectiveness of knowledge workers in distributed teams is ambiguous. In this study, we try to fill the gap in the literature.

This paper is structured as follows. First, we extract the 11 factors of KW construct in the virtual R&D teams' base on prior research. Next, structural equation modeling (SEM) is used as the analytical tool for testing the estimating and testing the KW construct measurement models. Then modify the preliminary KW construct model by fitting the model according to the SEM fitness indices and made a final measurement model. The paper infer with a discussion and future guidelines.

2. LITERATURE REVIEW

2.1 Knowledge worker role in the virtual R&D teams for new product development

Bal and Teo [13] developed a model for the effective virtual teams based on knowledge workers (people), processes and technology constructs considering 12 factors. To achieve high levels of performance, virtual teaming requires the co-ordinate development of KW, process and technology [14]. Bal and Teo [13] concluded that the success in implementing virtual team working is more about processes and KW than about technology. Virtual team members are required to take the initiative to coordinate and collaborate with team members, with other people in the organization, and with external partners [15]. Virtual teaming eliminates the necessity for physical co-location thus enabling manufacturers to rapidly and continuously collaborate with suppliers world-wide irrespective of geographical constraints [14]. From the knowledge worker point of view, the factors that required for effective virtual teams are unclear. We extracted 11-important factors related to a KW construct based on a comprehensive review of KW point of view in a virtual R&D team working (Table 1).

Table 1 Factors related to the knowledge worker construct in virtual teams

Factor short name	Factor full name	References
knoW1	Working together	[16]
knoW2	Interaction from inside	[15-16]
knoW3	Interaction from outside	[15-16]
knoW4	Interact with colleagues	[7]
knoW5	Online training and e-learning	[17]
knoW6	Consulting service (Consulting with others)	[18-19]
knoW7	Collaborating and making decisions with co-workers or supplier	[20-21]
knoW8	Facilitates cooperation between employees	[22]
knoW9	Facilitates introduction of new employees	[17, 23]
knoW10	Facilitates the management of NPD project	[10]
knoW11	Used by the competitor	[17, 24]

Virtual teams are similar to traditional teams in that they involve a group of people working together towards a common goal [17, 25]. Given that the team task is novel and members have no history of working together, the virtual team must create a shared way of operating in the of its inception [26]. Virtual team members essentially work with little or no face-to-face contact and focus on a finite lifespan or a temporal basis. Therefore, this implies a limited history of working together as well as less potential of working together in the future [27]. More research is needed on the degree if carrying out a work enhances a team's ability to continue working together in the future, which is an important construct to better understand the long viability of virtual teams [28]. The company's information systems are opened to its contributing companies (subcontractors, providers, distributors, etc.), allowing it to exchange information electronically with these agents [16].

2.2 Structural equation modeling (SEM)

Structural equation modeling (SEM) is a method of statistical analysis that is used to determine whether or not the data obtained in a study confirms the hypothesized relationships that are specified by the researcher [29]. SEM has become one of the preferred data analysis methods among empirical Operations Management (OM) researchers, and articles that employ SEM as the primary data analytic tool now routinely appear in major OM journals [30]. SEM permits complex phenomena to be statistically modeled and tested. SEM techniques are therefore becoming the preferred method for confirming (or disconfirming) theoretical models in a quantitative fashion [31]. Anderson and Gerbing [32] proposed two main components of models in SEM:

1. The measurement model, or factor model showing the relations between latent variables (construct) and their indicators (observed variables), followed by;
2. The structural model showing potential causal dependencies between endogenous and exogenous variables [31].

The measurement model provides an assessment of convergent and discriminant validity, and the structural model provides an assessment of nomological validity [31]. In this study, we only perform the first step of SEM, which is building and fitting the measurement model. The task involved in developing the measurement model is twofold:

3. To determine the number of factors to use in measuring each construct, and
4. To identify which items is to use in formulating each factor [33].

3. RESEARCH METHODOLOGY AND DATA COLLECTION

To build a measurement model on knowledge worker 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 is selected because; it is a cost effective and quick result to get feedback from the point

of view of the respondent [24, 34]. A Likert scale from one to five was used (1-Not important and 5-Extremely important). This set up gave respondents a series of attitude checking dimensions. The questionnaire was emailed to the managing director, R&D manager, the new product development manager, project and design manager and the appropriate people who were most familiar with the R&D activities in the firm.

Invitation via 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 2 Summarized online survey data collection

Numbers of emails sent enterprises	3625
Total responses (Click 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 [32] suggested using confirmatory factor analysis (CFA) for scale development because it affords stricter interpretation of unidimensionality than what is provided by more traditional approaches, such as coefficient alpha, item-total correlations, and exploratory factor analysis. The evidence that the measures were unidimensional, where a set of indicators (factors) shares only a single underlying construct, was assessed using CFA [32]. After data collection, the measures purification procedures should be used to assess their reliability, unidimensionality, discriminant validity, and convergent validity [32]. Hence, a preliminary descriptive analysis was performed in order to test the reliability on internal consistency. For reliability analysis, Cronbach's Alpha [35] was employed to each factor. A reliability test was carried out by SPSS 16 software to ensure the research finding have the ability to provide consistence results. All the 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. For cross checking the internal consistency, the knowledge worker construct with the 11 related factors define in a measurement model using AMOS 18 software. The factor loads of the indicators, which had Cronbach's α less than value 0.6 were deleted. So, the factors KnoW1, KnoW5, KnoW10 and KnoW11 exempted from further analysis. In general, the reliability of the questionnaire instruments demonstrated a good reliability across the samples.

Structural equation modeling (SEM) using AMOS 18 was employed for validation of the measurement model. This statistical analysis are estimated simultaneously for both the measurement and structural models [36]. To ensure that the factors make a right construct, the measurement model examined the model fit. Given this, the model assessed for the convergent and discriminant validity.

Convergent validity was established using a calculation of factor loading, average variance extracted (AVE) and composite reliability (CR). The factors that have standardized loadings exceeded 0.50, were maintained [36]. The initial measurement model was consisting of 11 factors (KnoW1 to KnoW11). After revising the measurement model by deleting KnoW1, KnoW5, KnoW10 and KnoW11, the AVE and CR were calculated. AVE larger than 0.5 is the threshold value [37]. CR is calculated by squaring the sum of loadings, then dividing it by the sum of squared loadings, plus the sum of the measurement error [38]. CR should be greater than 0.6 [39]. The measurement model shows inadequate convergent validity because of AVE = 0.483. We deleted the knoW6 which had smallest factor loading and then recalculated the CR and AVE. In this stage, the measurement model had adequate convergent validity since the calculated CR and AVE were 0.857and 0.501 respectively.

For discriminant validity, we performed AMOS software using maximum likelihood method (ML). We run the AMOS for the preliminary model and found a lack of model fit RMSEA = 0.127. Most of the rest of fit indices were in the acceptable range. Thus, referring to the AMOS modification indices (MI) KnoW2 factor that had the same effect of KnoW3 factor was deleted. With this modification, the measurement model well fitted.

4.1 Final measurement model

The final measurement model developed the base on the modified preliminary measurement model by modification indices guidelines. As demonstrated in Figure 1 each factor loading was above 0.61 and significant. Overall, the final measurement model produced good-fit indices (CMIN/DF = 2.116, RMR = .026, GFI = .983, NFI = .973, TLI = .971, CFI = .985, IFI = .985 and RMSEA = .068), providing an adequate model fit.

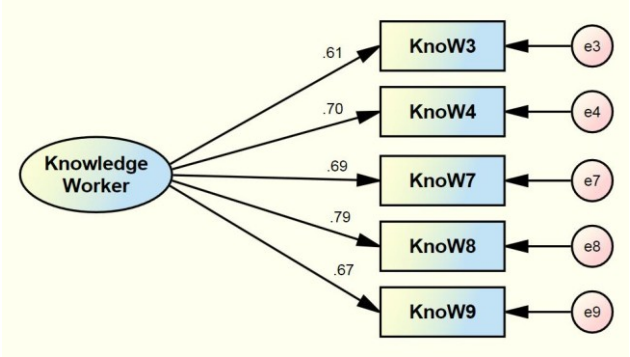

Figure 1 Final measurement model

5. DISCUSSIONS

The first data purification dropped KnoW1 (Working together), knoW5 (Online training and e-learning), KnoW10 (Facilitates the management of NPD project) and KnoW11 (Is used by the competitor). From the perception of knowledge workers in virtual R&D teams for developing collaborative tools, the deleted factors were not important compared with the remaining factors. While fitting the knowledge worker construct measurement model the factors knoW6 (Consulting service) and KnoW2 (Interaction from inside) were dropped. Modification indices (MI) based on regression weights show that KnoW2 and KnoW3 are

highly correlated, so one representative (KnoW3) from this group is adequate.

The results of the final measurement model of knowledge worker construct in virtual R&D team for developing a new product, shows the share of five factors, which are strongly correlated to the KW construct. The respondents asked to identify the requirements of the company in determining the appropriate collaborative tools for an effective new product development through virtual teams. Therefore, from knowledge worker point of view the remaining factors are highly important. Hence, new product development managers of enterprises should provide a platform for knowledge workers to interact and collaborate with each other in order to have an effective virtual R&D team.

6. CONCLUSIONS

Although, knowledge workers play an important role in the effectiveness of virtual R&D teams for new product development, research to date has explored the 11 factors for working together virtually. However, we still less than adequate knowledge about the factors which have the main contributions in the KW construct of the virtual R&D teams for new product development. The findings of this empirical study may extend the literatures and help to build a foundation for further understanding of the knowledge workers' role in the virtual R&D teams for new product development. The measurement model shows five factors that make the KW construct. These five factors can be sorted by their factor loading which are reflecting the factor weight. Therefore, the software developer or the managers of the NPD are able to provide a better platform for virtual team working by concentrating on the main factors.

Future research is needed to investigate the effects of each factor in the performance of the virtual R&D teams while the other constructs of virtual teams such as process and technology are present. A new SEM is needed to demonstrative the relationship between factors-constructs and constructs-constructs which is not investigated yet and not available in the literature.

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