Effective virtual teams for new product development

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EFFECTIVE VIRTUAL TEAMS FOR NEW PRODUCT DEVELOPMENT

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Abstract:

Literature shows the factors that impact on the effectiveness of virtual teams for new product development, are still ambiguous. To address this problem, we developed a research design that included a literature review, a preliminary model and field survey. The literature identified factors which impact on the effectiveness of virtual teams. These factors were then modified by a field survey. We explore the relationship between knowledge worker (people), process and technology in virtual teams. The results of the study suggest that technology and process are tightly correlated and need to be considered early in virtual teams. Software as a service, web solution, report generator and tracking system in effective virtual teams should consider for leading such a new phenomena.

Keywords

Virtual teams; Collaboration; Questionnaires; Communication; Information; Integration; Performance; Success; Cross-Functional Teams; Product Development;

1 INTRODUCTION

Nowadays, a virtual team allows work to be carried out over computer networks and reduces the need for teams to be collocated. 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 organization tasks" (Ale Ebrahim et al., 2009b). 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). Different products may need different processes. A new product idea needs to be conceived, selected, developed, tested and launched to the market (Martinez-Sanchez et al., 2006). 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 (Kratzer et al., 2005). As a result, firms are finding that internal development of all technology needed for new products and processes are difficult or impossible. They must increasingly receive technology from external sources (Stock and Tatikonda, 2004).

Virtualization in NPD has recently started to make serious headway due to developments in technology - virtuality in NPD which is now technically possible (Leenders et al., 2003). As product development becomes the more complex, supply chain 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 (Anderson et al., 2007). Although the use of the internet in NPD has

received notable attention in the literature, little is written about collaborative tool and effective virtual teams for NPD (Ale Ebrahim et al., 2009a).

This paper is structured as follows. First, the motivation for the study is initially described. Next, we draw on prior research to derive the items that comprise the effectiveness of virtual teams. Then we present our methods and results of our analyses. The paper infers with a discussion and future guidelines.

2 WHAT IS NEED FOR EFFECTIVE VIRTUAL TEAM?

A review of the literature shows the factors that influence the effectiveness of virtual teams are still ambiguous (Ale Ebrahim et al., 2009d). Most of the accepted challenges of an effective virtual team working, focus on ensuring good communication among all members of the distributed team (Anderson et al., 2007). For example, Jarvenpaa and Leidner (1999) found that regular and timely communication feedback was a key to building trust and commitment in distributed teams. A study by Lin et al. (2008) suggests that social dimensional factors need to be considered early in the virtual team creation process and are critical to the effectiveness of the team. Communication is a tool that directly influences the social dimensions of the team and in addition performing the team has a positive impact on satisfaction with the virtual team.

For teams moving from co-location to virtual environments, an ability to adapt and change can be a long process riddled with trial and error scenarios. This process is seen as necessary to encourage effective virtual teams (Kirkman et al., 2002). Despite weak ties between virtual team members, ensuring lateral communication may be adequate for effective virtual team performance. In terms of implementation, lateral communication in both virtual context and composition teams can be increased by reducing the hierarchical structure of the team (i.e. a

flatter reporting structure and/or decentralization) and the use of enabling computer-mediated communication tools (Wong and Burton, 2000).

Malhotra and Majchrzak's (2004) study of 54 effective virtual teams found that creating a state of shared understanding about goals and objectives, task requirements and interdependencies, roles and responsibilities, and member expertise had a positive effect on output quality. As criteria, effectiveness ratings were Hertel et al. (2005) collected from the team managers both at the individual and at the team level. The results of the field study showed good reliability of the task work-related attributes, teamwork-related attributes, and attributes related to tele-cooperative work.

Shachaf and Hara (2005) suggest four dimensions of effective virtual team leadership:

1. Communication (the leader provides continuous feedback, engages in regular and prompt communication, and clarifies tasks);
2. Understanding (the leader is sensitive to schedules of members, appreciates their opinions and suggestions, cares about member's problems, gets to know them, and expresses a personal interest in them);
3. Role clarity (the leader clearly defines responsibilities of all members, exercises authority, and mentors virtual team members); and
4. Leadership attitude (the leader is assertive yet not too "bossy," caring, relates to members at their own levels, and upholds a consistent attitude over the life of the project).

Bal et al. (2001b, 1999) by observation and interview identified 12 elements for effective virtual team working. As illustrated in Figure 1. The Bal and Gundry (2001b, 1999) model are used as the basic framework in this paper.

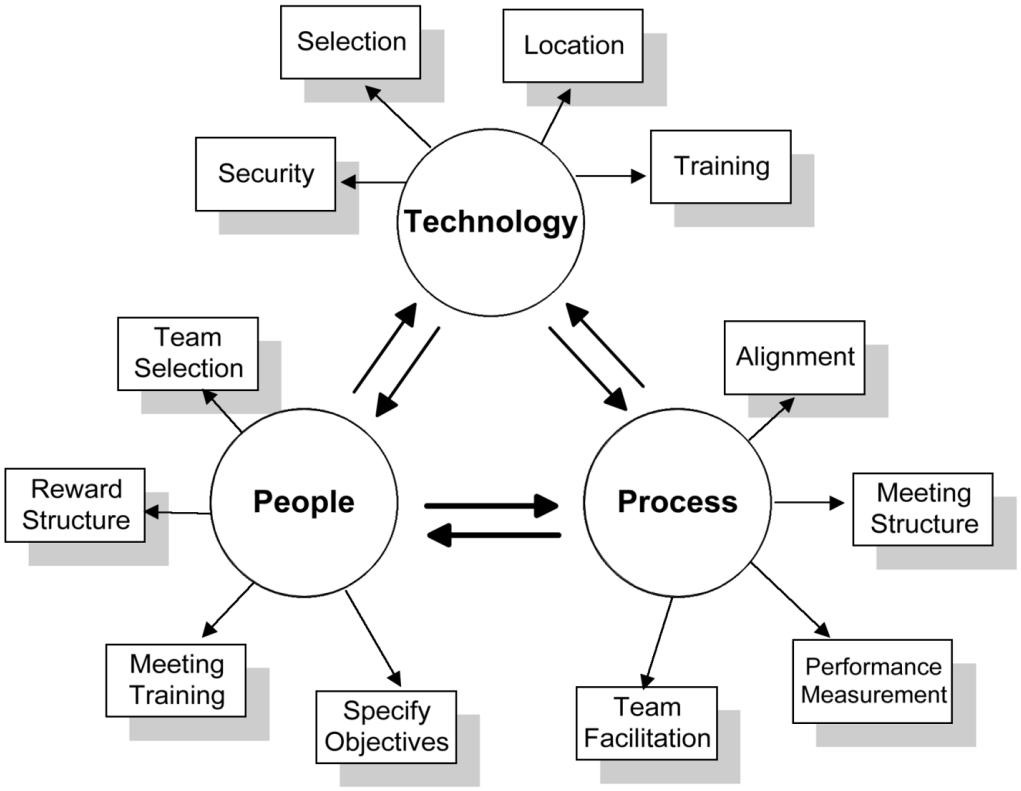

Figure 1 Model for effective virtual team working (Source (Bal and Gundry, 1999))

2.1 Virtual team working: technology point of view

2.1.1 Selection:

Simple transmission of information from a point A to a point B is not enough; the virtual environment presents significant challenges to effective communication (Walvoord et al., 2008). Being equipped with even the most advanced technologies is not adequate to make a virtual team effective, since the internal group dynamics and external support mechanisms must also be

present for a team to succeed in the virtual world (Lurey and Raisinghani, 2001). Information richness seemed to be the most important criterion for technology selection; and the greatest impediment to the effectiveness of virtual teams was the implementation of technology (Mikkola et al., 2005). Virtual teams are technology-mediated groups of people from different discipline that work on common tasks (Dekker et al., 2008). So the way the technology is implemented seems to make the virtual team outcome more or less likely (Anderson et al., 2007). Table 1 matrix assists the virtual team facilitator in choosing the suitable technology based upon the purpose of the meeting.

Table 1 Tools for virtual teams (Adopted from Thissen et al. (2007))

Tool	Examples	Uses and Advantages	Immediacy	Sensory Modes
Instant Messaging and Chat	• Yahoo Messenger • MSN Messenger • AOL Instant Messenger • Skype	• Instant interaction • Less intrusive than a phone call • View who is available • Low cost • Low setup effort	• Synchronous or asynchronous	• Visual • Text and limited graphics
Groupware / Shared Services	• Lotus Notes • Microsoft Exchange • Novell Groupwise	• Calendars • Contact Lists • Arrange meetings • Cost and setup effort vary	• Asynchronous	• Visual
Remote Access and Control	• NetMeeting • WebEx • Remote Desktop • pcAnywhere	• User controls a PC without being on-site • Cost varies • Setup varies	• Synchronous	• Visual • Audio • Tactile
Web Conferencing	• NetMeeting • WebEx • Meeting Space • GoToMeeting	• Live audio • Dynamic video • Whiteboard • Application sharing • Moderate cost and setup effort	• Synchronous	• Visual • Unlimited graphics • Optional audio
File Transfer	• File Transfer Protocol (FTP) • Collaborative Websites • Intranets	• Share files of any type • Cost varies • Moderate setup effort	• Asynchronous	• Varies with file content
Email	• Many vendors and • free applications	• Send messages or files • Cost and setup effort vary	• Asynchronous	• Visual • Audio in attached files
Telephone	• “Plain Old Telephone Service” (POTS) • Voice Over Internet Protocol (VOIP)	• Direct calls • Conference calls • Cost varies • Low setup effort	• Synchronous • Asynchronous for voice mail	• Audio

2.1.2 Location:

Virtual team allowed organizations to access the most qualified individuals for a particular job regardless of their location and provide greater flexibility to individuals working from home or on the road (Bell and Kozlowski, 2002). Table 2 shows the relationship between tool, time and space in virtual teams.

2.1.3 Training:

Suggestions for the training of remote managers and virtual team development can be found in (Hertel et al., 2005). The results of Anderson et al. (2007) systematic lab study confirmed many of the observations, including explicit preparation and training for virtual teams as a way of working collaboratively. Fuller et al., (2006) indicated that in the case of computer collective efficacy, computer training related to more advanced skills sets may be useful in building virtual team efficacy. Hertel et al. (2005)suggested that training led to increased cohesiveness and team satisfaction.

Table 2 Time /Space matrix (Adapted from Bouchard and Cassivi (2004))

	Same space	Different space
Same time Synchronous	Face-to-face meeting, Brainstorming, Vote, PC and projector Electronic white board, GDSS, Chat	Chat, Tele-conference, Video-conference, Liaison satellite, Audio-conference, Shared white board, Shared application
Different time Asynchronous	Team room, Document management system, Discussion forum, E-mail, Workflow, Project management	E-mail, Workflow, Document sharing , Discussion forum, Group agenda Cooperative hypertext and organizational memory, Version control Meeting scheduler

2.1.4 Security:

Virtual team working to involve exchange and manipulation of sensitive information and data through the Internet therefore, security is always an important issue of concern (Bal and Teo, 2001b). Team leaders should identify the special technological and security level needs of the virtual team and their team members (Hunsaker and Hunsaker, 2008).

2.2 Virtual team working: people point of view

2.2.1 Team selection:

One of the key factors which distinguish successful teams from unsuccessful ones, is team selection (Ale Ebrahim et al., 2009d). Virtual teams can be designed to include the people most suited for a particular project (Bell and Kozlowski, 2002). Besides making sure that the project is clearly defined, outcome priorities and a supportive team climate are established. Virtual team needs to select members with the necessary skills (Hunsaker and Hunsaker, 2008). Selection of virtual team members is particularly difficult because of the geographical and organizational separation involved (Bal and Gundry, 1999).

2.2.2 Reward structure:

Developing a fair and motivating reward system is another important issue at the beginning of virtual teamwork (Bal and Teo, 2001a, Hertel et al., 2005). Virtual team performance must be recognized and rewarded (Bal and Gundry, 1999). Lurey and Raisinghani (2001) in a survey in an effort to determine the factors that contribute to the success of a virtual team, found that reward systems ranked strongly among the external support mechanisms for virtual teams.

2.2.3 Meeting training:

Comparing teams with little and extensive training, Bal and Gundry (1999) remarked a significant drop in performance as both teams went live using the system. However, the latter then improved its performance at a faster rate than the former. Training is a key aspect that cannot be neglected in team building. Virtual team members need different types of training

compared to ordinary teams. The training includes self-managing skills, communication and meeting training, project management skills, technology training, etc. (Bal and Teo, 2001b).

2.2.4 Specify an objective:

While direct leadership strategies are possible in conventional teams, members of virtual teams might be managed more effectively by empowerment and by delegating managerial functions to the members (Hertel et al., 2005). Such an approach changes the role of a team manager from traditional controlling into more coaching and moderating functions (Kayworth and Leidner, 2002). Virtual team leaders should identify commonalities among members early on, while focusing the team on achieving key performance objectives (Ale Ebrahim et al., 2009d).

2.3 Virtual team working: process point of view

2.3.1 Alignment:

The company's processes need to be re-aligned with the capabilities of virtual teams contrary to face-to-face teams. This involves an understanding of the virtual team processes and the 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).

2.3.2 Meeting structure:

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 lack of physical interactions and informal relationships decrease the cohesiveness of virtual teams. Formal practices and

routines designed to formally structure the task, was reported to lead to higher quality output of virtual teams (Massey et al., 2003). The physical absence of a formal leader exacerbates the lack of extrinsic motivation (Kayworth and Leidner, 2002). In virtual teams that rarely meet face-to-face, team leaders often have no choice but to impose a formal team structure. Synchronous written documents helped virtual teams overcome challenges associated with spoken language, and this enabled teams to overcome challenges associated with asynchronous and lean written communication (Shachaf, 2008).

2.3.3 Performance measurement:

Kirkman and Rosen, et al. (2004) study on performing virtual teams, shows a positive correlation between empowerment and virtual team performance. High-performance teams are differentiated by passionate dedication to goals, emotional bonding among team members and identification, and a balance between unity and respect for individual differences (Ale Ebrahim et al., 2009d).

2.3.4 Team facilitation:

Team members must have crystal clear rules and responsibilities. The rule should be accountable and visible. Virtual team members may feel less accountable for results under lack of visibility circumstances. Therefore, explicit facilitation of a virtual team takes on heightened importance for team working. Temporal coordination mechanisms such as scheduling deadlines and coordinating the pace of effort are recommended to increase vigilance and accountability (Massey et al., 2003).

3 NEW PRODUCT DEVELOPMENT AND VIRTUALITY

Product development is defined by different researchers is slightly different ways, but generally it is the process that covers product design, production system design and product introduction processes and start of production (Johansen, 2005). New product development (NPD) has long been recognized as one of the corporate core functions (Huang et al., 2004). The rate of market and technological changes has accelerated in the past years and this turbulent environment needs new methods and techniques to bring successful new products to the marketplace (González and Palacios, 2002). Particularly, for companies with short product life cycles, it is important to quickly and safely develop new products and new product platforms that fulfill reasonable demands on quality, performance, and cost (Ottosson, 2004). The world market requires short product development times (Starbek and Grum, 2002). Therefore, in order to successfully and efficiently get all the experience needed in developing new products and services, more and more organizations are forced to move from traditional face-to-face teams to virtual teams or adopt a combination between the two types of teams (Precup et al., 2006). Given the complexities involved in organizing face-to-face interactions among team members and the advancements in electronic communication technologies, firms are turning toward employing virtual NPD teams (Badrinarayanan and Arnett, 2008, Jacobsa et al., 2005, Schmidt et al., 2001). New product development requires the collaboration of new product team members both within and outside the firm (Martinez-Sanchez et al., 2006, McDonough et al., 2001, Ozer, 2000). NPD teams are necessary in most businesses (Leenders et al., 2003). In addition, the pressure of globalization competition companies faced increased pressures to build critical mass, reach new markets, and plug skill gaps , NPD efforts are increasingly being pursued across multiple nations through all forms of organizational arrangements (Cummings and Teng, 2003). Given the

resulting differences in time zones and physical distances in such efforts, virtual NPD projects are receiving increasing attention (McDonough et al., 2001, Ale Ebrahim et al., 2010). The use of virtual teams for new product development is rapidly growing and organizations can be dependent on it to sustain competitive advantage (Taifi, 2007). So, virtual teams provide valuable input for new product development (Ale Ebrahim et al., 2009c).

4 PRIMARY MODELS AND HYPOTHESES

We adapted from Bal and Gundry (2001b, 1999), a new primary model with respect to the requirements of the company in determining the appropriate design tools and methods for an effective new product development in virtual teams (Figure 2).

4.1 Hypotheses

Clearly, throughout a review of the existing literature, there remains a gap with respect to the requirements of the company in determining the appropriate design tools and methods for an effective new product development in virtual teams. This research proposes the following hypotheses in order to collect the requirements:

H1. Technology is positively related to process in virtual teams.

H2. Technology is positively related to the knowledge workers in virtual teams.

H3. The process and knowledge worker is positively correlated in virtual teams.

H4. There is not any significant difference between the origins of virtual teams.

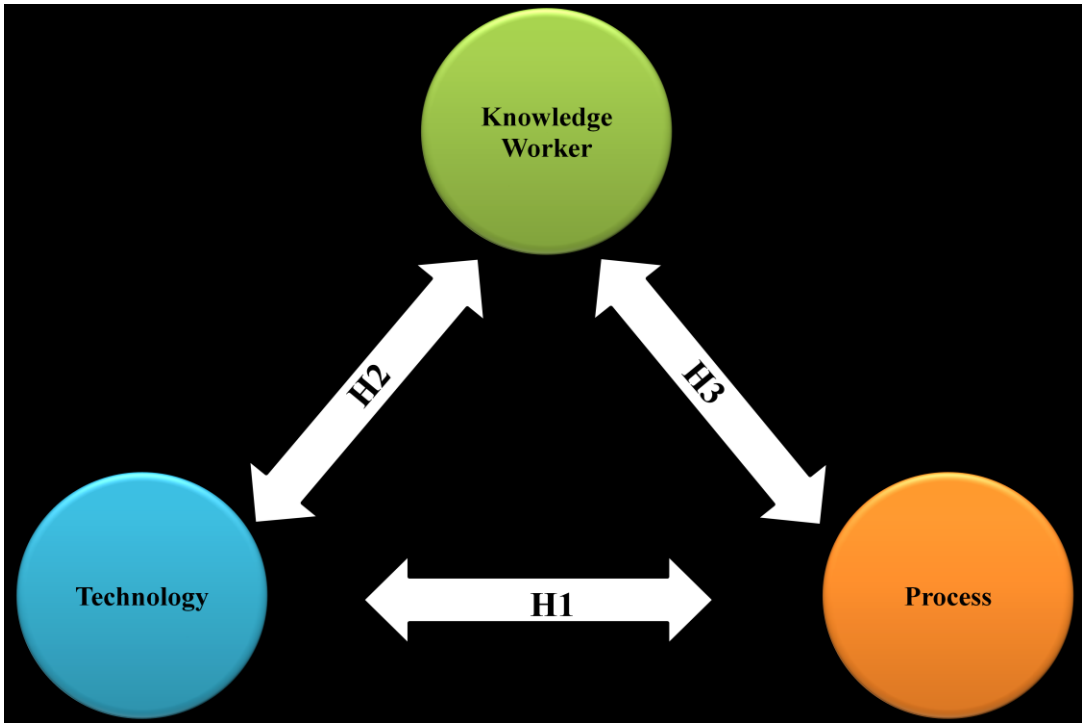

Figure 2 The preliminary model for evaluating the effectiveness of virtual teams

5 RESEARCH METHOD AND DATA COLLECTION

To test the hypotheses, we conducted a web-based survey mainly conducting Malaysian and Iranian Manufacturing companies, in a random sample of small and medium enterprises. A survey was developed to collect the data. A Likert scale from 1 to 5 was used. This set up gave respondents a series of attitude dimensions. For each dimension, the respondent was asked whether, and how strongly, they agree or disagree to each dimension using a point rating scale. The questionnaire was emailed to the managing director, R&D manager, the new product development manager, project and design manager and appropriate people who were most familiar with the R&D activities in the firm. 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). Denscombe (2006) findings encourage social researchers to use web-based questionnaires with confidence and the data produced by web-based questionnaires is

equivalent to that produced by paper-based questionnaires. Other authors highlighted the data provided by Internet methods are of at least as good quality as those provided by traditional paper-and-pencil methods (Gosling et al., 2004, Deutskens et al., 2006). Invitation e-mails were sent to each respondent, reaching 1500 valid email accounts, with reminders following one month later. 240 enterprises submitted responses, for an overall response rate of 12%. Table 3 presents respondent demographics (missing data deducted). The survey limited to the sample size and sample population in the specified regions.

Table 3 Frequency Distributions of Demographic Variables (N=240)

Variable	Frequency distribution N (%)	
Gender	Male	202 (85.6)
	Female	34 (14.4)
Country	Iran	136 (56.7)
	Malaysia	74 (30.8)
	Others (Developing)	15 (6.2)
	Others (Developed)	15 (6.2)
Age group	Up to 21	2 (0.9)
	21-34	103 (44.6)
	35-49	101 (43.7)
	50-64	23 (10.0)
	Over 65	2 (0.9)
Job Roles	Managing director	51 (22.7)
	R&D Manager	25 (11.1)
	New Product Development Manager	27 (12.0)
	Project Manager	43 (19.1)
	Design manager	7 (3.1)
	Others	72 (32.0)
Main Business	Automotive/vehicle and components	89 (37.1)
	Electronic products and components	30 (12.5)
	Fabricated metal products	13 (5.4)
	Electrical machinery, apparatuses, appliances, or supplies	12 (5.0)
	Machinery/ Industrial equipment	9 (3.8)
	Home appliances	12 (5.0)
	Pharmaceutical or Chemical products (including cosmetics, paints)	4 (1.7)
	Paper products	4 (1.7)
	Plastic products	3 (1.2)
	Food and Food packaging	1 (0.4)
	Instrumentation equipment	4 (1.7)
	Textile	2 (0.8)
	Oil & Gas	11 (4.6)
	Education	14 (5.8)
	Others	32 (13.3)

6 ANALYSIS AND RESULTS

For reliability analysis, Cronbach's Alpha (Cronbach, 1951) was employed to measure internal consistency of each construct. A reliability test was carried out to ensure the research finding have the ability to provide consistence results. As shown in Table 4, all the items with Cronbach's α greater than 0.6 were included in the analysis and the rest omitted from analysis. In general, the reliability of the questionnaire's instruments is acceptable.

Table 4 Summary of the final measures and reliabilities

Factor and variable name		Items	Mean *	Std. Deviation	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Knowledge worker (N=218)	Pe1	Working together	4.037	1.029	0.560	0.872
	Pe2	Interaction from inside	3.995	0.912	0.641	0.867
	Pe3	Interaction from outside	3.824	1.001	0.634	0.867
	Pe4	Interact with colleagues	3.982	0.991	0.649	0.866
	Pe5	Online training and e-learning	3.401	1.143	0.597	0.87
	Pe6	Consulting service	3.472	0.998	0.624	0.868
	Pe7	Collaborating and making decisions with co-workers or supplier	3.863	0.943	0.642	0.867
	Pe8	Facilitates cooperation between employees	3.876	0.917	0.651	0.867
	Pe9	Facilitates introduction of new employees	3.553	1.079	0.654	0.866
	Pe10	Facilitates the management of NPD project	3.706	1.014	0.654	0.866
	Pe11	Is used by the competitor	3.106	1.238	0.301	0.893
Process (N=211)	Pr1	Project control (such as Intranet based project status tracking system)	3.64	1.101	0.650	0.928
	Pr2	Project reporting system (such as MS-Project reporting system)	3.82	1.026	0.666	0.927
	Pr3	Making business together	3.648	0.943	0.627	0.928
	Pr4	Reduce traveling time and cost	3.862	1.024	0.722	0.925
	Pr5	Reduces the number of working hours need to solve the task	3.827	1.008	0.725	0.925
	Pr6	Collaborative solutions	3.701	0.916	0.694	0.926
	Pr7	Facilitates data collection in new product development project	3.813	0.952	0.744	0.924
	Pr8	Interact with customers for gathering new product features	3.83	0.973	0.674	0.926
	Pr9	Provide quantities answer	3.384	0.985	0.664	0.927
	Pr10	Generate an easy interpret answer	3.333	0.981	0.642	0.927

	Pr11	Ease of generating reports	3.678	1.028	0.740	0.924
	Pr12	Ease of data entry	3.775	0.937	0.737	0.924
	Pr13	Ability to accommodate multiple users	3.905	1.019	0.667	0.927
Technology (N=218)	Te1	Use internet and electronic mail	4.202	0.986	0.528	0.945
	Te2	Online meeting on need basis	3.535	1.13	0.764	0.941
	Te3	Web conferencing	3.381	1.17	0.778	0.941
	Te4	Seminar on the Web	3.134	1.172	0.742	0.942
	Te5	Shared work spaces	3.507	1.063	0.749	0.942
	Te6	Video conferencing	3.172	1.161	0.737	0.942
	Te7	Audio conferencing	3.221	1.146	0.735	0.942
	Te8	Online presentations	3.453	1.107	0.809	0.941
	Te9	Share documents (off-line)	3.601	1.075	0.637	0.944
	Te10	Share what's on your computer desktop with people in other locations (in real time)	3.196	1.206	0.577	0.945
	Te11	Do not install engineering software (get service through web browser)	3.179	1.211	0.590	0.945
	Te12	Access service from any computer (in Network)	3.542	1.041	0.688	0.943
	Te13	Standard phone service and hybrid services	3.576	1.07	0.511	0.946
	Te14	Access shared files anytime, from any computer	3.686	1.01	0.625	0.944
	Te15	Web database	3.649	0.995	0.704	0.943
	Te16	Provide instant collaboration	3.595	1.037	0.654	0.943
	Te17	Software as a service (eliminating the need to install and run the application on the own computer)	3.531	1.07	0.666	0.943
	Te18	Virtual research center for product development	3.455	1.078	0.681	0.943
	Te19	Can be integrated/compatible with the other tools and systems	3.688	1.139	0.613	0.944

*Frequency values - 1: Not important; 2: Slightly important; 3: Important; 4: Quite important; 5: Extremely important

To conclude whether the partial correlation of the knowledge workers, variables were small, the Bartlett's Chi-square test of sphericity and Kaiser-Meyer-Olkin (KMO) was used to measure sampling adequacy (Fathian et al., 2008). Table 5 summarizes the results of KMO, which is 0.878 and significant value for Bartlett's test is less than 0.05, which means there is a good correlation.

Table 5 KMO and Bartlett's Test results

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0. 878
Bartlett's Test of Sphericity	Approx. Chi-Square	679.744
	df	28
	Sig.	.000

An exploratory factor analysis was conducted on eight knowledge worker factors after taking off Pe1, Pe5 and Pe11 which had Cronbach's α less than 0.6. Using a Principle Component Analysis with a Varimax Rotation and an Eigenvalue of 1 as the cut-off point (Akgün et al., 2008) and an absolute value of a loading greater than 0.5 (Fathian et al., 2008). Factor loading shows only one component extracted. So, all eight items in the knowledge workers can be grouped into a single factor.

The same procedures were performed on process and technology factors. The items and their factor loadings after Exploratory Factor Analysis, Eigenvalue, and percentage of variance, are shown in Table 6, Table 7, Table 8 and Table 9. The 13 process items and the 15 technology items are divided into two different groups, which had an Eigenvalue greater than one.

Table 6 Factor analysis results on 13 process items

	Initial Eigenvalues			Rotation Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	7.158	55.062	55.062	4.255	32.733	32.733
2	1.126	8.662	63.724	4.029	30.991	63.724
3	.951	7.314	71.039			
4	.737	5.670	76.708			
5	.544	4.185	80.893			
6	.461	3.544	84.437			
7	.445	3.422	87.859			
8	.415	3.192	91.051			
9	.333	2.558	93.609			
10	.304	2.338	95.947			
11	.222	1.707	97.654			
12	.173	1.331	98.985			
13	.132	1.015	100.000			

Extraction Method: Principal Component Analysis

Table 7 Rotated Component Matrix sorted by size for 13 process items

Items	Component	
	1	2
Pr11	.783	.326
Pr9	.781	.225
Pr10	.767	.213
Pr12	.751	.350
Pr8	.724	.302
Pr13	.576	.443
Pr1	.202	.804
Pr2	.229	.792
Pr3	.248	.724
Pr6	.352	.711
Pr5	.484	.620
Pr4	.482	.614
Pr7	.527	.594

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization

Table 8 Factor analysis results on 15 technology items

	Initial Eigenvalues			Rotation Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	8.471	56.471	56.471	5.581	37.205	37.205
2	1.681	11.207	67.677	4.571	30.472	67.677
3	.902	6.011	73.688			
4	.642	4.281	77.969			
5	.530	3.536	81.505			
6	.500	3.336	84.840			
7	.406	2.709	87.550			
8	.356	2.376	89.926			
9	.321	2.143	92.069			
10	.297	1.980	94.048			
11	.252	1.678	95.726			
12	.224	1.495	97.221			
13	.164	1.092	98.313			
14	.156	1.039	99.352			
15	.097	.648	100.000			

Extraction Method: Principal Component Analysis

Table 9 Rotated Component Matrix sorted by size for 15 technology items

Items	Component	
	1	2
Te3	.862	.293
Te7	.846	.232
Te4	.846	.265
Te6	.845	.263
Te2	.840	.272
Te8	.793	.388
Te5	.677	.426
Te9	.566	.386
Te17	.206	.816
Te15	.292	.764
Te14	.203	.737
Te19	.248	.730
Te12	.299	.713
Te18	.384	.687
Te16	.335	.656

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization

We then try to identify the confirmed factors based on the principle of being concise without losing clarity of meaning. After extracting the factors, items with higher loadings are considered more important and have greater influence on the name of selected reduced factors. The names and contents of the two derived factors on process items are:

1- Factor FPr1: it consists of items Pr8 to Pr13 which is “Interact with customers for gathering new product features “, “Provide quantities answer”, “Generate an easy interpret answer”, “Ease of generating reports”, “Ease of data entry” and “Ability to accommodate multiple users” respectively. This factor is named “Reports generator” because of Pr11 has higher loading factor (0.783).

2- Factor FPr2: It consists of Pr1 to Pr7 which are “Project control”, “Project reporting system”, “Making business together”, “Reduce traveling time and cost”, “Reduces the number of working hours need to solve the task”, “Collaborative solutions”, and “Facilitates data collection in new product development project” respectively. Since Pr1 has a higher loading (0.804), this factor’s named “Tracking system“.

Consequently, the names and contents of two derived factors on technology items are:

1- Factor FTe1: it consists of items Te2 to Te9 which is “Online meeting “, “Web conferencing”, “Seminar on the Web”, “Shared work spaces”, “Video conferencing”,” Audio conferencing”, “Online presentations”, and “Share documents” respectively. This factor is named “Web solution” because Te3 has a higher loading factor (0.862).
2- Factor FTe2: It consists of items Te12 and Te14 to Te19 which are “Access service from any computer (in Network)”, “Access shared files anytime, from any computer”, “Making business together”, “Web database”, “Provide instant collaboration”, “Software as a service”, “Virtual research centre for product development”, and “Can be integrated/compatible with the other tools and systems” respectively. Since Te17 has a higher loading (0.816) this factor’s named “Software as a service (SaaS)“.

Analysis of the Pearson’s correlations indicated a number of positive relationships between the variables themselves. The knowledge worker had significant associations to process and technology, respectively (see Table 10). The correlations may vary country to the country as illustrated in

Table 11 and Table 12. Fisher's Exact Test analysis supported there are no significant differences ($p > 0.427$) between selected countries in terms of knowledge worker, process and technology in virtual teams.

Table 10 Descriptive statistics and correlations between variables (N=240)

Variable	Mean	Std. dev.	1	2
1. Knowledge worker	36.65	13.672		
2. Process	42.25	17.191	0.792*	
3. Technology	58.72	24.153	0.773*	0.853*

*. Correlation is significant at the 0.01 level (2-tailed).

Table 11 Descriptive statistics and correlations between variables in Iran (N=136)

Variable	Mean	Std. dev.	1	2
1. Knowledge worker	36.14	14.251		
2. Process	42.66	17.165	0.791*	
3. Technology	60.77	24.429	0.838*	0.865*

*. Correlation is significant at the 0.01 level (2-tailed).

Table 12 Descriptive statistics and correlations between variables in Malaysia (N=74)

Variable	Mean	Std. dev.	1	2
1. Knowledge worker	38.08	12.210		
2. Process	42.78	16.770	0.811*	
3. Technology	56.95	21.301	0.684*	0.795*

*. Correlation is significant at the 0.01 level (2-tailed).

Table 13 Hypothesis testing results

Hypotheses	Correlation/P value	Conclusion
H1. Technology is positively related to process in virtual teams.	0.853*	Supported
H2. Technology is positively related to the knowledge workers in virtual teams.	0.773*	Supported
H3. The process and knowledge worker is positively correlated in virtual teams.	0.792*	Supported
H4. There is not any significant difference between the origins of virtual teams.	0.427**	Supported

Note: *: $p < 0:01$, **: $p < 0:05$

The mean scores for frequency of use to exchange business information are illustrated in Table 14. E-mail is the most frequently used tool for all teams in Malaysia and Iran. Personal telephone call is second most frequently used tool in selected countries. Malaysian firms used more face-to-face interaction than Iranian ones. On the other hand, team base communication technologies such as shared database, group telephone conference, electronic whiteboard and video conference were not often used. Video conference, although used less than once a month in Iranian samples, are most often used by Malaysian firms. Video conferencing may prove effective in bringing remote members together if made available to the teams, and this might be a fruitful area for future research (Lurey and Raisinghani, 2001). Along with Lurey, and Raisinghani (2001) recommendation, item Te6 asked about the need for video conference as a tool for virtual team and, mean of (N=218) 3.172 was obtained which means it is important for the team members.

Table 14 Mean* scores for frequency of use exchange business information tools in Iran and Malaysia

Tools	Iranian teams (N=86)	Malaysian teams (N=31)
E-mail	4.62	4.97
Personal telephone call	4.54	4.63
Fax	4.02	4.00
Face-to-face interaction	3.65	4.23
Shared database/groupware	3.09	2.74
Meeting facilitation software	2.49	2.71
Web collaborative tool	2.42	2.65
Electronic newsletter	2.38	2.59
Voice mail	2.32	3.00
Electronic whiteboard	2.15	2.77
Group telephone conference	2.09	2.76
Video conference	1.85	2.43

*Frequency values- 1: never; 2: once a month; 3: once a week; 4: a few times a week; 5: daily

All factors are summarized in Figure 3. This new model is based on the Bal and Gundry (1999) model with several adjustments derived from data analysis and survey findings. The model provides an overview of effective virtual teams for new product development in selected developing countries.

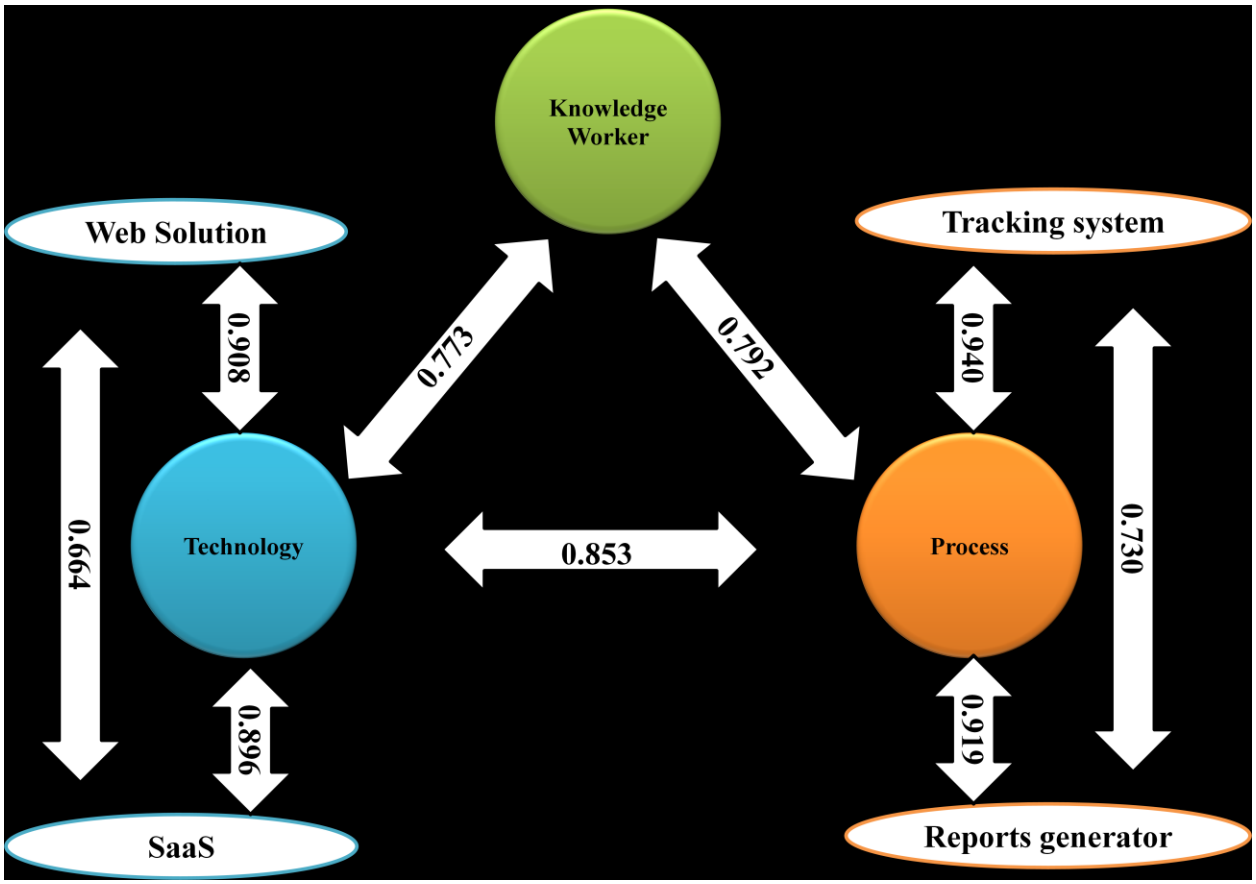

Figure 3 The new model for effectiveness of virtual teams (Correlation is significant at the 0.01 level (2-tailed)).

7 RESEARCH LIMIT AND FUTURE RESEARCH DIRECTIONS

The model for effective virtual teams developed earlier had made an initial attempt to identify the relationships between the knowledge worker, process and technology factors that were seen as the most critical in the literature. The literature review had focused only on published refereed journal and conference papers, so some important studies may have been excluded from this

research. Therefore, it is possible that some factors which were excluded from the framework could be important for evaluation of virtual teams. The study was limited to the sample size and sample population. Future research needs to examine the model and verify it by a larger sample of virtual teams from different sectors since this study was limited to manufacturing sector. In a larger sample, it is possible to compare the results between countries more precisely. We have identified twelve new crucial factors, which differ from precedent, for moving from the team working to successful virtual teaming in new product development.

8 CONCLUSION

This paper is a review by the literature and a field survey identifying the key factors that need to be considered in effective virtual teams. These findings provide an important step in studying how virtual team efficacy is formed and what its consequences are in the context of virtual teams. The results of the study indicate that technology and process are tightly correlated and need to be considered early in virtual teams. Along with Bal and Teo (2001b) and Ale Ebrahim et al. (2009d) findings, success in implementing virtual team working is more about the knowledge worker than technology and process. The survey result showed, all eight items in the knowledge workers remain while the rest is reduced into two main factors. Software as a service, web solution, report generator and tracking system in effective virtual teams should be taken into account for leading such a new phenomena. E-mail is the most frequently used tool for all teams in Malaysia and Iran; therefore, a manager of virtual teams should considerably provide an infrastructure for effective communications between team members.

Future research would now seem to be essential for developing a comprehensive study, combining survey with a case study in different size of companies (e.g. multinational companies and small and medium enterprises) and various types of activities (e.g. research and development

and new product development). Such a study needs to investigate the model and verify it by a larger sample of virtual teams from different sectors. In a larger sample, it is possible to compare the results between countries more precisely.

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