

Ale Ebrahim, Nader; Ahmed Shamsuddin; Abdul Rashid, Salwa Hanim; Taha, Zahari

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Full Length Research Paper

Effective virtual teams for new product development

Nader Ale Ebrahim^{1*}, Shamsuddin Ahmed¹, Salwa Hanim Abdul Rashid¹ and Zahari Taha²

¹Department of Engineering Design and Manufacture, Faculty of Engineering, University of Malaya,
50603, Kuala Lumpur, Malaysia.

²Faculty of Manufacturing Engineering and Management Technology, University Malaysia Pahang,
26300 Gambang, Pahang, Malaysia.

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At present, the existing literature shows that the factors which influence the effectiveness of virtual teams for new product development are still ambiguous. To address this problem, a research design was developed, which includes detailed literature review, preliminary model and field survey. From literature review, the factors which influence the effectiveness of virtual teams are identified and these factors are modified using a field survey. The relationship between knowledge workers (people), process and technology in virtual teams is explored in this study. The results of the study suggest that technology and process are tightly correlated and need to be considered early in virtual teams. The use of software as a service, web solution, report generator and tracking system should be incorporated for effectiveness virtual teams.

Key words: Virtual teams, collaboration, questionnaires, communication, information, integration, performance, success, cross-functional teams, product development.

INTRODUCTION

Nowadays, virtual teams enable work to be carried out over computer networks and reduce 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). The statement “We are becoming more virtual all the time!” is often heard in many global corporations today (Chudoba et al., 2005). 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. Therefore, firms have no choice but to disperse their new product units to access such dispersed knowledge and skills (Kratzer et al., 2005). Consequently, firms are faced with the problem that the internal development of all technologies required for new products and processes are difficult or impossible. Firms must increasingly receive technology from external sources (Stock and Tatikonda, 2004).

Virtualization in NPD has recently started to make a serious headway due to developments in technology - virtuality in NPD is now technically possible (Leenders et al., 2003). Supply chains need to collaborate more closely compared with the past as product development becomes more complex. These collaborations almost always involve individuals from different locations, and therefore, virtual teamwork supported by information technology (IT) offer notable potential benefits (Anderson et al., 2007). Although the use of the internet in NPD has received considerable attention in the literature, little is known regarding collaborative tools and effective virtual

*Corresponding author E-mail:
alebrahim@siswa.um.edu.my

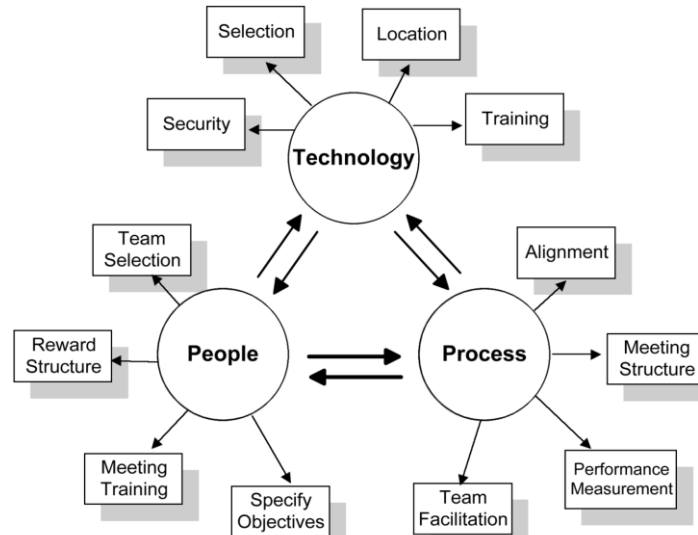


Figure 1. Model for effective virtual teamwork (Source (Bal and Gundry, 1999)).

teams for NPD (Ale Ebrahim et al., 2009a).

THE NEED FOR EFFECTIVE VIRTUAL TEAMS

A review of the literature reveals that the factors which influence the effectiveness of virtual teams are still ambiguous (Ale Ebrahim et al., 2009d). One of the notable challenges for effective virtual teams is ensuring good communication amongst all members of the distributed teams (Anderson et al., 2007). Jarvenpaa and Leidner (1999) found that regular and timely communication feedback is a key to building trust and commitment in distributed teams. A study by Lin et al. (2008) suggested that social dimensional factors need to be considered early during 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, which improves team performance and has a positive impact on satisfaction within the virtual team.

For teams moving from collocation 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 (that is, a flatter reporting structure and/or decentralization) and the use of 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. Hertel et al. (2005) collected effectiveness ratings from team managers both at the individual team levels. The results of the field study showed good reliability of task work-related attributes, teamwork-related attributes, and attributes related to tele-cooperative work.

Shachaf and Hara (2005) proposed 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 the members' schedules, appreciates their opinions and suggestions, cares about their 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.
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.

From observations and interviews, Bal et al. (2001b, 1999) identified 12 elements for effective virtual teamwork, as illustrated in Figure 1. The Bal and Gundry (2001b, 1999) model was used as the basic framework in this paper.

Table 1. Tools for virtual teams.

Tool	Examples	Uses and Advantages	Immediacy	Sensory Modes
Instant Messaging and Chat	<ul style="list-style-type: none"> • Yahoo Messenger • MSN Messenger • AOL Instant Messenger • Skype 	<ul style="list-style-type: none"> • Instant interaction • Less intrusive than a phone call • View who is available • Low cost • Low setup effort 	<ul style="list-style-type: none"> • Synchronous or asynchronous 	<ul style="list-style-type: none"> • Visual • Text and limited graphics
Groupware / Shared Services	<ul style="list-style-type: none"> • Lotus Notes • Microsoft Exchange • Novell Groupwise 	<ul style="list-style-type: none"> • Calendars • Contact Lists • Arrange meetings • Cost and setup effort vary 	<ul style="list-style-type: none"> • Asynchronous 	<ul style="list-style-type: none"> • Visual
Remote Access and Control	<ul style="list-style-type: none"> • NetMeeting • WebEx • Remote Desktop • pcAnywhere 	<ul style="list-style-type: none"> • User controls a PC without being on-site • Cost varies • Setup varies 	<ul style="list-style-type: none"> • Synchronous 	<ul style="list-style-type: none"> • Visual • Audio • Tactile
Web Conferencing	<ul style="list-style-type: none"> • NetMeeting • WebEx • Meeting Space • GoToMeeting 	<ul style="list-style-type: none"> • Live audio • Dynamic video • Whiteboard • Application sharing • Moderate cost and setup effort 	<ul style="list-style-type: none"> • Synchronous 	<ul style="list-style-type: none"> • Visual • Unlimited graphics • Optional audio
File Transfer	<ul style="list-style-type: none"> • File Transfer Protocol (FTP) • Collaborative Websites • Intranets 	<ul style="list-style-type: none"> • Share files of any type • Cost varies • Moderate setup effort 	<ul style="list-style-type: none"> • Asynchronous 	<ul style="list-style-type: none"> • Varies with file content
Email	<ul style="list-style-type: none"> • Many vendors and free applications 	<ul style="list-style-type: none"> • Send messages or files • Cost and setup effort vary 	<ul style="list-style-type: none"> • Asynchronous 	<ul style="list-style-type: none"> • Visual • Audio in attached files
Telephone	<ul style="list-style-type: none"> • "Plain Old Telephone Service" (POTS) • Voice Over Internet Protocol (VOIP) 	<ul style="list-style-type: none"> • Direct calls • Conference calls • Cost varies • Low setup effort 	<ul style="list-style-type: none"> • Synchronous • Asynchronous for voice mail 	<ul style="list-style-type: none"> • Audio

Adopted from Thissen et al. (2007).

Virtual teamwork: Technology point of view

Selection

A simple transmission of information from point A to point B is insufficient as the virtual environment presents significant challenges for effective communication (Walvoord et al., 2008). Being equipped with even the most advanced technology is inadequate 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 seems to be the most important criterion for technology selection and the greatest impediment to the effectiveness of virtual teams is the implementation of technology (Mikkola et al., 2005). Virtual teams are technology-mediated groups of people from different disciplines that work on common tasks (Dekker et al., 2008). Hence, the way the technology is

implemented appears to be a factor which makes a virtual team's outcome more or less likely successful (Anderson et al., 2007). The matrix in Table 1 assists the virtual team facilitator in choosing the suitable technology based upon the purpose of the meeting.

Location

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

Training

Suggestions for training remote managers and virtual

Table 2. Time /Space matrix.

	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

Adapted from Bouchard and Cassivi (2004).

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

Security

Since virtual teamwork involves exchanging and manipulating sensitive information and data via the Internet, 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).

Virtual teamwork: People point of view

Team selection

Team selection is one of the key factors which distinguish successful teams from unsuccessful ones (Ale Ebrahim et al., 2009d). Virtual teams can be designed to include people who are most suited for a particular project (Bell and Kozlowski, 2002). In this manner, the project will be clearly defined, and the outcome priorities and supportive team climate will be established. Selection of members with the necessary skills is crucial for virtual teams (Hunsaker and Hunsaker, 2008). Selection of virtual team members is particularly difficult due to the geographical and organizational separation involved (Bal and Gundry, 1999).

Reward structure

Developing a fair and motivating reward system is another significant 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) found that reward systems ranked strongly among the external support mechanisms for virtual teams in a survey to determine the factors that contribute to the success of a virtual team.

Meeting training

Comparing teams with little and extensive training, Bal and Gundry (1999) noted 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 which cannot be neglected in team building. Virtual team members require different types of training compared to ordinary teams. The training includes self-managing skills, communication and meeting training, project management skills, technology training, et cetera (Bal and Teo, 2001b).

Specify an objective

While direct leadership strategies are possible in conventional teams, members of virtual teams may 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).

Virtual teamwork: Process point of view

Alignment

The company's processes need to be re-aligned with the

capabilities of virtual teams, unlike face-to-face teams.

This involves an understanding of virtual team processes and existing processes (Bal and Gundry, 1999). However, the key elements in knowledge sharing are hardware, software as well as the ability and willingness of team members to actively participate in the knowledge sharing process (Rosen et al., 2007).

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 are 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 structure tasks formally were 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). For virtual teams which rarely meet face-to-face, team leaders often have no choice but to impose a formal team structure. Synchronous written documents assist virtual teams to overcome challenges associated with spoken language, and this enables teams to overcome challenges associated with asynchronous and lean written communication (Shachaf, 2008).

Performance measurement

Kirkman and Rosen et al. (2004) studied the performance of virtual teams and showed 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).

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 due to lack of visibility circumstances. Therefore, explicit facilitation of virtual teams is of extreme importance for teamwork. Temporal coordination mechanisms such as scheduling deadlines and coordinating the pace of effort are recommended to increase vigilance and accountability (Massey et al., 2003).

NEW PRODUCT DEVELOPMENT AND VIRTUALITY

Product development is defined by different researchers in 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 to bring successful new products to the marketplace (González and Palacios, 2002). This is particularly true for companies with short product life cycles, whereby it is important to develop new products and new product platforms quickly and safely, which 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 obtain all the experience needed for 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, in the haste of global competition, companies faced increasing pressure 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 in which organizations can rely on to sustain competitive advantage (Taifi, 2007). Hence, virtual teams provide valuable input for new product development (Ale Ebrahim et al., 2009c).

PRIMARY MODELS AND HYPOTHESES

In this study, a new primary model is adapted from Bal and Gundry (2001b, 1999), with respect to the requirements of the company in determining the

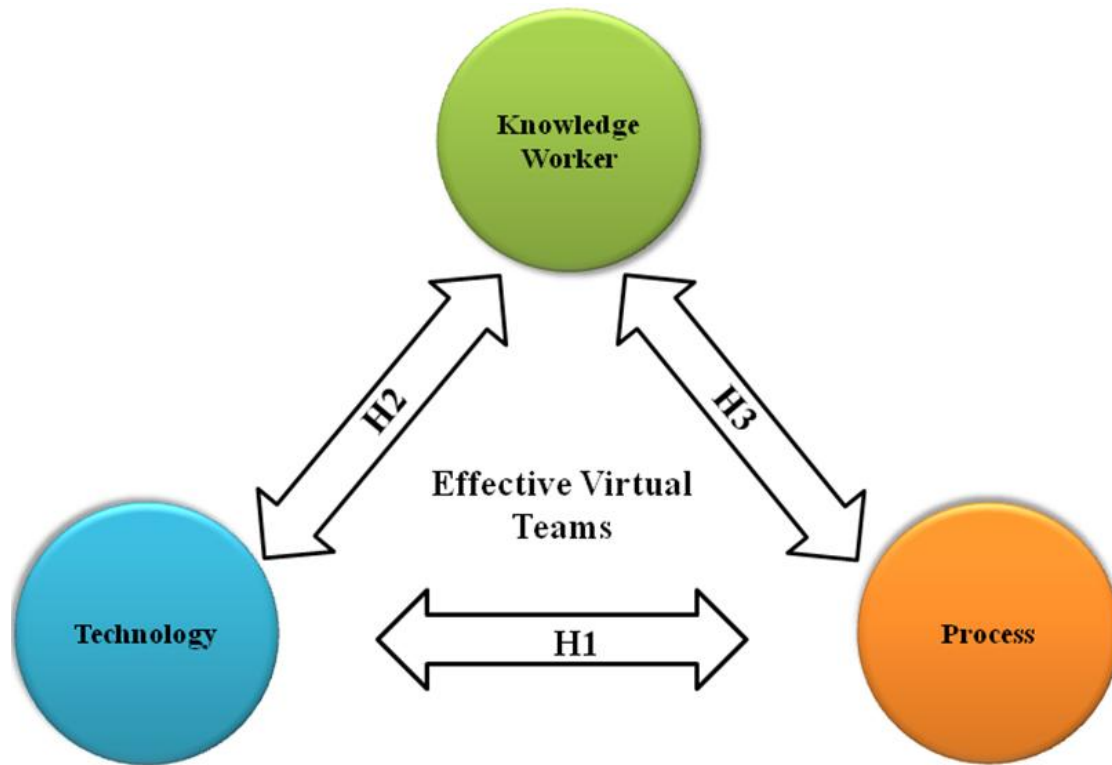


Figure 2. Preliminary model for evaluating the effectiveness of virtual teams.

appropriate design tools and methods for an effective new product development in virtual teams (Figure 2).

Hypotheses

From a review of the existing literature, it is evident that there remains a gap with respect to the requirements of the company in determining the appropriate design tools and methods for effective new product development in virtual teams. This research proposes the following hypotheses in order to fulfill the requirements:

H₁: Technology is positively correlated to Process in virtual teams.

H₂: Technology is positively correlated to Knowledge Workers in virtual teams.

H₃: Process and Knowledge Workers are positively correlated in virtual teams.

H₄: There is an insignificant difference between the origins of virtual teams.

METHODOLOGY

To test the hypotheses, a Web-based survey was carried out in a random sample of small and medium enterprises in Malaysian and Iranian manufacturers. A survey is developed for data collection,

whereby a Likert scale from 1 to 5 is used. This scale provides respondents with a series of attitude dimensions. For each dimension, the respondent is asked whether, and how strongly, they agree or disagree to each dimension using a point rating scale. The questionnaire is e-mailed to the Managing Director, R&D Manager, New Product Development Manager, Project and Design Manager and appropriate personnel who are most familiar with R&D activities within 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). The findings of Denscombe (2006) encouraged social researchers to use Web-based questionnaires with confidence. 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 are sent to each respondent, reaching 1500 valid e-mail accounts, with reminders following one month later. 240 enterprises submit responses, giving an overall response rate of 12%. Table 3 presents the respondents' demographics upon deduction of missing data. The survey is limited to the sample size and population in the specified regions.

RESULTS AND ANALYSIS

For reliability analysis, Cronbach's Alpha (Cronbach, 1951) is employed to measure the internal consistency of each construct. A reliability test is carried out to ensure that the research findings have the ability to produce

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
	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 and Gas
	11 (4.6)
	Education
	14 (5.8)
	Others
	32 (13.3)

consistent results. From Table 4, all items having a Cronbach's α greater than 0.6 are included in the analysis, while the rest are omitted from the analysis. In general, the reliability of the questionnaire's instruments is acceptable.

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

the results indicate that there is good correlation.

An exploratory factor analysis is performed on eight knowledge worker factors after removing Pe1, Pe5 and Pe11, which have a Cronbach's α of 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 that only one component can be extracted. Therefore, all eight items in knowledge workers can be grouped into a single factor.

The same procedure is performed on process and technology factors. The items and their factor loadings

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 Interactions from inside	3.995	0.912	0.641	0.867
	Pe3 Interactions from outside	3.824	1.001	0.634	0.867
	Pe4 Interactions 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 suppliers	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 competitors	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 Reduce the number of working hours needed 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 Interaction with customers for gathering new product features	3.83	0.973	0.674	0.926
	Pr9 Provide quantitative answer	3.384	0.985	0.664	0.927
	Pr10 Generate an easy and interpretable 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

Table 4. Contd.

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.

Table 5. KMO and Bartlett's Test results.

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.878
	Approx. Chi-Square	679.744
Bartlett's Test of Sphericity	df	28
	Sig.	0.000

Table 6. Factor analysis results on 13 process items.

Component	Initial eigenvalues			Rotation sums of squared loadings		
	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	0.951	7.314	71.039			
4	0.737	5.670	76.708			
5	0.544	4.185	80.893			
6	0.461	3.544	84.437			
7	0.445	3.422	87.859			
8	0.415	3.192	91.051			
9	0.333	2.558	93.609			
10	0.304	2.338	95.947			
11	0.222	1.707	97.654			
12	0.173	1.331	98.985			
13	0.132	1.015	100.000			

Extraction method: Principal Component Analysis.

after Exploratory Factor Analysis, Eigenvalue, and percentage of variance, are shown in Tables 6, 7, 8 and 9, respectively. The 13 process items and 15 technology items are divided into two different groups, which have an Eigenvalue greater than one.

The confirmed factors are then identified based on conciseness, without losing clarity of meaning. Upon extraction of the factors, the 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: This consists of Items Pr8 through Pr13, which are *"Interact with customers for gathering new product features"*, *"Provide quantitative answer"*, *"Generate an easy and interpretable answer"*, *"Ease of generating reports"*, *"Ease of data entry"* and *"Ability to*

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

Items	Component	
	1	2
Pr11	0.783	0.326
Pr9	0.781	0.225
Pr10	0.767	0.213
Pr12	0.751	0.350
Pr8	0.724	0.302
Pr13	0.576	0.443
Pr1	0.202	0.804
Pr2	0.229	0.792
Pr3	0.248	0.724
Pr6	0.352	0.711
Pr5	0.484	0.620
Pr4	0.482	0.614
Pr7	0.527	0.594

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

Table 7. Factor analysis results on 15 technology items.

Component	Initial eigenvalues			Rotation sums of squared loadings		
	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	0.902	6.011	73.688			
4	0.642	4.281	77.969			
5	0.530	3.536	81.505			
6	0.500	3.336	84.840			
7	0.406	2.709	87.550			
8	0.356	2.376	89.926			
9	0.321	2.143	92.069			
10	0.297	1.980	94.048			
11	0.252	1.678	95.726			
12	0.224	1.495	97.221			
13	0.164	1.092	98.313			
14	0.156	1.039	99.352			
15	0.097	0.648	100.000			

Extraction method: Principal component analysis.

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

Items	Component	
	1	2
Te3	0.862	0.293
Te7	0.846	0.232
Te4	0.846	0.265
Te6	0.845	0.263
Te2	0.840	0.272
Te8	0.793	0.388
Te5	0.677	0.426
Te9	0.566	0.386
Te17	0.206	0.816
Te15	0.292	0.764
Te14	0.203	0.737
Te19	0.248	0.730
Te12	0.299	0.713
Te18	0.384	0.687
Te16	0.335	0.656

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

accommodate multiple users", respectively. This factor is given the name *"Reports generator"* due to the fact that Pr11 has the highest loading factor (0.783).

2. Factor FPr2: This consists of Items Pr1 through Pr7, which are *"Project control"*, *"Project reporting system"*, *"Making business together"*, *"Reduce traveling time and cost"*, *"Reduce 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 the highest loading (0.804), this factor is given the name *"Tracking system"*.

In a similar manner, the names and contents of the two derived factors based on technology items are:

1. Factor FTe1: This consists of Items Te2 through Te9, which are *"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"* since Te3 has the highest loading factor (0.862).

2. Factor FTe2: This 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 the highest loading (0.816), this factor is named *"Software as a service (SaaS)"*.

Analysis of Pearson's correlations indicates a number of positive relationships among the variables. Knowledge Workers is strongly correlated to Process and Technology, respectively (Table 10). The correlations vary by country, as illustrated in Tables 11 and 12. Fisher's Exact Test analysis support the fact that are insignificant differences ($p > 0.427$) between selected countries in terms of Knowledge Workers, Process and Technology in virtual teams.

The mean scores for frequency of use to exchange business information are illustrated in Table 11. Electronic mail is the most frequently used tool for all teams in Malaysia and Iran. Personal telephone call is the second most frequently used tool in both countries. Malaysian firms use more face-to-face interactions compared to Iranian firms. On the other hand, team-based communication technologies such as shared

Table 8. Descriptive statistics and correlations between variables (N=240).

Variable	Mean	Std. dev.	1	2
1. Knowledge workers	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 9. Descriptive statistics and correlations between variables in Iran (N=136).

Variable	Mean	Std. dev.	1	2
1. Knowledge workers	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 10. Descriptive statistics and correlations between variables in Malaysia (N=74).

Variable	Mean	Std. dev.	1	2
1. Knowledge workers	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 11. Hypothesis testing results.

Hypotheses	Correlation/P value	Conclusion
H ₁ : Technology is positively correlated to Process in virtual teams.	0.853*	Supported
H ₂ : Technology is positively correlated to Knowledge Workers in virtual teams.	0.773*	Supported
H ₃ : Process and Knowledge Workers are positively correlated in virtual teams.	0.792*	Supported
H ₄ : There is an insignificant difference between the origins of virtual teams.	0.427**	Supported

*, p < 0:01, **, p < 0:05.

database, group telephone conference, electronic whiteboard and video conference are not often used. Although video conference is used less than once a month in Iranian firms, this tool is most often used by Malaysian firms. Video conferencing may prove effective in bringing remote members together if such tool is made available to the teams, and this may be a fruitful area for future research (Lurey and Raisinghani, 2001). Item Te6 addresses the need for video conferencing as a tool for virtual teams and a mean score of (N=218) 3.172 is attained, which indicates that this tool is essential for virtual team members. This finding agrees with the recommendation by Lurey and Raisinghani (2001).

The factors are summarized in Figure 3. This new model is based on Bal and Gundry (1999)'s model, whereby several modifications are derived from data analysis and survey findings. The model provides an overview of effective virtual teams for new product development in selected developing countries, namely, Malaysia and Iran.

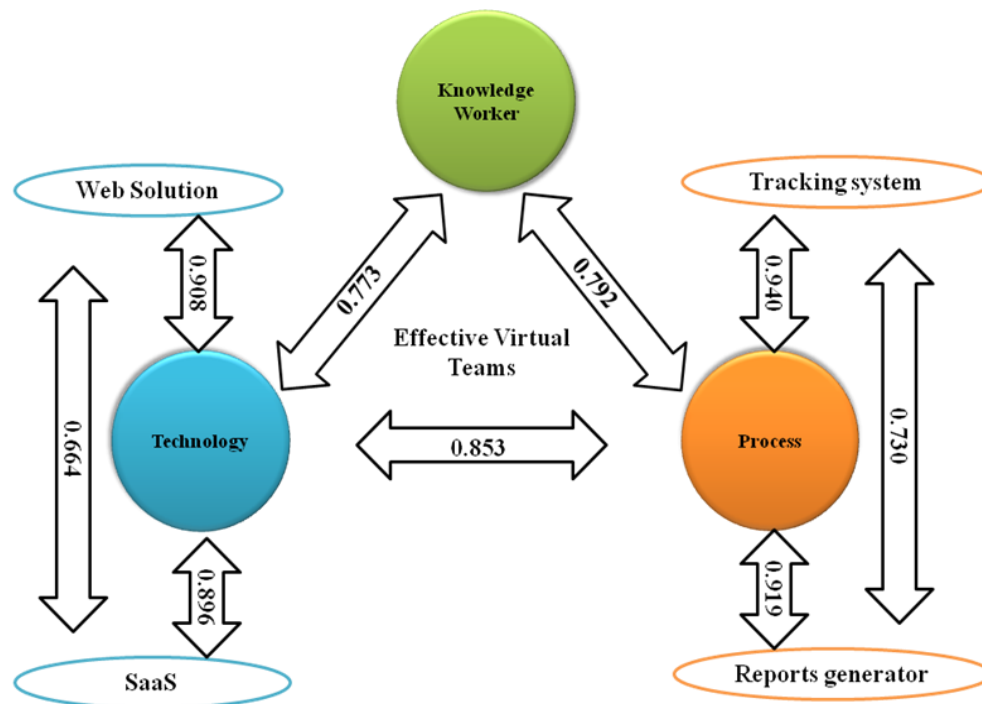
Research limitations and directions for future research directions

The model developed for effective virtual teams is an

Table 12. Mean* scores for frequency of use for 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.

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

initial attempt to identify the relationships between Knowledge Workers, Process and Technology factors, which are seen to be critical factors in the literature. The literature review is carried out based primarily on published refereed journal and conference papers, and thus, a number of important studies may have been excluded from this research. Therefore, it is possible that

several factors which are excluded from the framework could be important for evaluation of virtual teams. The study is limited by the sample size and population. Future research is required to examine the model and verify it by a larger sample of virtual teams from different sectors since this study is constrained to the manufacturing sector. With a larger sample, it is possible to compare the

results between countries more precisely. Twelve crucial factors have been identified in this research to move forward from conventional teamwork to successful virtual teamwork in new product development.

Conclusions

This paper is comprises of a literature review and field survey to identify the key factors which should be considered to create effective virtual teams. The findings provide a useful insight into 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. It is found that the role of Knowledge Workers in virtual teams is significant, which agrees well with the findings of Bal and Teo (2001b) and Ale Ebrahim et al. (2009d). The survey results reveal that all eight items in the Knowledge Workers factor remained while the remaining items are reduced into two main factors. Future research is needed to investigate the individual effects of Knowledge Workers, Technology and Process on virtual team effectiveness. *“Software as a service”, “Web solution”, “Report Generator” and “Tracking system in effective virtual teams”* should be taken into account in future research. E-mail is the most frequently used tool for all teams in Malaysia and Iran and therefore, managers of virtual teams should provide enhanced infrastructures for effective communications between team members.

Future research is essential to develop a comprehensive study which combines survey and case studies in companies of different sizes (e.g. multinational companies, and small and medium enterprises) and various types of activities (for example, research and development and new product development). Such a study is crucial to further develop the model and verify such a model using a larger sample of virtual teams from different sectors. With a larger sample, it is possible to compare the results between countries more precisely.

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