



Virtual R&D Teams: Innovation and Technology Facilitator

Nader Ale Ebrahim

Department of Engineering Design
and Manufacture Faculty of Engineering
University of Malaya Kuala Lumpur, Malaysia
alebrahim@perdana.um.edu.my

Shamsuddin Ahmed

Department of Engineering Design
and Manufacture Faculty of Engineering
University of Malaya Kuala Lumpur, Malaysia
ahmed@um.edu.my

Zahari Taha

Department of Engineering Design
and Manufacture Faculty of Engineering
University of Malaya Kuala Lumpur, Malaysia
zahari_taha@um.edu.my

Abstract

Innovation is becoming the most important key issue for company's success in the 21st century. In the competitive environment is necessary for the enterprises to put together different capabilities and services with the goal. It's a widely accepted that innovation is better achieved by working in team. The employed web services technology, although very popular nowadays but it is still not mature enough, so dealing with it can bring new findings. Virtual teams base on information technology are formed to facilitate transnational innovation processes and it should be noted that innovation has a positive impact on corporate performance. Information and communication technology has brought about significant changes in organizations and produced important benefits, including in the areas of innovation which is recognized as a prime source of national competitive advantage.

This contribution proposes a conceptual model for understanding and analyzing the process of virtual R&D team as an innovation and technology assimilation facilitator. The context of the knowledge-based economy introduces a major shift from serial to simultaneous R&D in the way of idea conception to technology creation is conceived. This paper briefly reviews the existing perspectives on virtual teams and their effect on innovation and technology. It also discusses the main characteristics of virtual teams and clarifies the differences aspects of virtual team application in the topic. To support the theoretical analysis, this paper provides a comprehensive review based on authentic and reputed publications. We argue that scanty research has been conducted to facilitate understanding the problem of systematically governing creative innovation toward a technology through virtual R&D teams.

Keywords Virtual R&D team; Innovation, Idea creation, Technology, Conceptual model

INTRODUCTION

Research and development and as a result, technology have tremendously improved the quality of human life over the last five decades [1]. Timely information can be crucial to the success of businesses. Inadequate knowledge about or access to new technologies and know-how is a central concern for many enterprises. One of the best ways of promoting innovation is to ensure that individuals and firms benefit from the results of their



research efforts [2]. Innovation is a broad term that encompasses virtually any new development in firms. It can involve creating or re-engineering products or services to meet new market demand, introducing new processes to improve productivity, developing or applying new marketing techniques to expand sales opportunities, and incorporating new forms of management systems and techniques to improve operational efficiency.

The use of teams has increased significantly as organizations (both public and private) have turned more and more jobs over to team-based structures. Teams are now being used in innovative ways in strategic planning, flexible-jobbing initiatives, global networks, the horizontal organization, and the virtual organization [3]. Now, due to communication technology improvements and continued globalization, virtual teams have increased rapidly worldwide [4]. With rare exceptions all organizational teams are virtual to some extent [5]. Virtual teams are assumed to be part of normal business life [6]. It is commonly agreed that virtual teams produce a greater quantity of ideas and information than individuals acting alone. So delaying with virtual team can bring new opportunity to facilitate technology creation and innovation in enterprises.

This paper proposes a model for effective virtual team working and understanding the process of virtual R&D team as an innovation and technology assimilation facilitator. After briefly reviews the existing perspectives on virtual teams and their effect on innovation, the main characteristics of virtual teams and clarifies the differences aspects of virtual team application in the topic will discussed.

VIRTUAL TEAMS: ORIGINS AND TRENDS

By the mid-1990s, increasing numbers of companies such as Goodyear, Motorola, Texas Instruments, and General Electric had begun exporting the team concept to their foreign affiliates in Asia, Europe, and Latin America to integrate global human resource practices [7]. This era is growing popularity for virtual team structures in organizations [8, 9]. Nowadays we have moved away from working with people who are in our visual proximity to working with people around the globe [10].

DEFINITION OF VIRTUAL TEAM

Along with Bal and Teo [11] it could be concluded that a team will become virtual if it meets four main common criteria and other characteristics that are summarized in Table 1. Geographically dispersed teams allow organizations to hire and retain the best people regardless of location. The temporary aspect of the team appears less emphasized [12] although [11, 13, 14] included temporary in virtual team definition but some authors like Gassmann and Von Zedtwitz [15] use may be temporary for some team members.

A summary of the definition of virtual team may be taken as: "small temporary groups of geographically, organizationally and/or time dispersed knowledge workers who coordinate their work predominantly with electronic information and communication technologies in order to accomplish one or more organization tasks".

Table 1 Common criteria of virtual team



Characteristics of virtual team	Descriptions	References
Common criteria	1. Geographically dispersed (over different time zones)	[12, 14, 16-19]
	2. Driven by common purpose(guided by a common purpose)	[11, 15, 17, 20, 21]
	3. Enabled by communication technologies	[11, 12, 18, 19]
	4. Involved in cross-boundary collaboration	[11, 15, 21, 22]
Other characteristics	1. It is not a permanent team	[11, 13, 14, 23, 24]
	2. Small team size	[11]
	3. Team member are knowledge workers	[11, 25]
	4. Team members may belong to different companies	[16, 24]

DIFFERENT ASPECT OF VIRTUAL TEAM AND ITS APPLICATION

Generally, we can differentiate various forms of “virtual” work depending on the number of persons involved and the degree of interaction between them. The first is “*telework*” (telecommuting) which is done partially or completely outside of the main company workplace with the aid of information and telecommunication services.”*Virtual groups*“ exist when several teleworkers are combined and each member reports to the same manager. In contrast, a “*virtual team*” exists when the members of a virtual group interact with each other in order to accomplish common goals. Finally, “*virtual communities*” are larger entities of distributed work in which members participate via the Internet, guided by common purposes, roles and norms. In contrast to virtual teams, virtual communities are not implemented within an organizational structure but are usually initiated by some of their members. Examples of virtual communities are Open Source software projects [20]. Cascio and Shurygailo [23] have clarified the difference form of virtual team by classifying it with respect to two primary variables namely, the number of location (one or more) and the number of managers (one or more) Table 2 illustrates this graphically. Therefore there are four categories of teams.

Table 2: Forms of Virtual Teams [23]

		Managers	
		One	Multiple
Locations	One	Teleworkers	Matrixed Teleworkers
	Multiple	Remote Team	Matrixed Remote Teams

EXAMPLES OF USES OF VIRTUAL TEAM

Working in today’s business world is like working in a world where the sun never sets. Rezgui [21] investigates the effectiveness of virtual teams, and any other suitable form of virtual collaboration, in the Construction sector and explores the factors that influence their successful adoption. May and Carter [26] in their case study of virtual team working in the European automotive industry have shown that enhanced communication and collaboration between geographically distributed engineers at automotive manufacturer and supplier sites make them get benefits are better quality, reduced costs and a reduction in the time-to-market (between 20% to 50%) for a new product vehicle. New product development (NPD) requires the collaboration of new product team members both within and outside the firm [27-29]. Given the resulting differences in time zones and physical distances in such efforts, virtual NPD projects are receiving increasing attention [28]. The use of virtual teams

for new product development is rapidly growing and organizations can be dependent on it to sustain competitive advantage [30]. The collaboration in product development can help enterprises reduce product development cycle time by 40 percent [31].

BENEFITS AND DRAW BACK OF VIRTUAL TEAM

During the last decade, words such as “virtual”, “virtualization”, “virtualized” have been very often advocated by scholars and practitioners in the discussion of social and economic issues[32] but the advantages and pitfalls of virtual team is concealed. The availability of a flexible and configurable base infrastructure is one of the main advantages of agile virtual teams. Virtual R&D teams which members do not work at the same time or place [33] often face tight schedules and a need to start quickly and perform instantly [34]. Virtual team may allow people to collaborate more productivity at a distance, but the tripe to coffee corner or across the hallway to a trusted colleague is still the most reliable and effective way to review and revise a new idea [35]. As a drawback, virtual teams are particularly vulnerable to mistrust, communication break downs, conflicts, and power struggles [36]. On the other hand, virtual teams reduce time-to-market [26]. Lead Time or Time to market has been generally admitted to be one of the most important keys for success in manufacturing companies [37]. Table 3 summarizes some of the main advantages and Table 4 some of the main disadvantages associated with virtual teaming. Clearly the rise of network technologies has made the use of virtual teams feasible [38].

Table 3: some of the main advantages associated with virtual teaming

Advantages	Reference
Reducing relocation time and costs, reduced travel costs (Virtual teams overcome the limitations of time, space, and organizational affiliation that traditional teams face [39])	[9, 28, 40-49]
Reducing time-to-market [Time also has an almost 1:1 correlation with cost, so cost will likewise be reduced if the time-to market is quicker [50]]	[26, 37, 43, 44, 49, 51-58]
More effective R&D continuation decisions	[59, 60]
Able to tap selectively into center of excellence, using the best talent regardless of location	[9, 42, 44, 46, 61-65]
Better team outcomes (quality, productivity, and satisfaction)	[39, 66, 67]
Higher team effectiveness and efficiency	[26, 68]

Table 4: some of the main disadvantages associated with virtual teaming

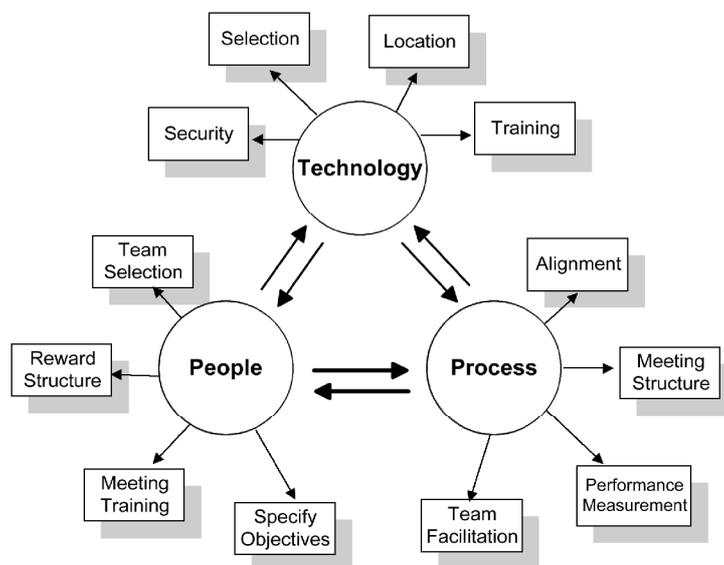
Disadvantages	references
Decrease monitoring and control of activities	[69]
Vulnerable to mistrust, communication break downs, conflicts, and power struggles	[4, 9, 30, 36, 70]
Challenges of determining the appropriate task technology fit	[64, 71-75]
Cultural and functional diversity in virtual teams lead to differences in the members' thought processes. Develop trust among the members are challenging	[34, 43, 64, 65, 73, 74, 76-79]

WHAT IS NEEDED FOR EFFECTIVE VIRTUAL TEAM

A review of the literature shows the factors that impact on the effectiveness of virtual teams are still ambiguous. Many of the acknowledged challenges of effective virtual team working focus on ensuring good communication among all members of the distributed team [80]. For example, Jarvenpaa and Leidner [81] found that regular and timely communication feedback was key to building trust and commitment in distributed teams. Lin et al.[82] indicate that social dimensional factors need to be considered early on 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 the performance of the team has a positive impact on satisfaction with the virtual team.

Malhotra and Majchrzak's [83] 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.[20] 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.

Bal and Teo [84] similar to their study in [85] by observation and interview identified 12 elements for effective virtual team working. It is illustrated in Figure 1. The Bal and Gundry [84, 85] model is used as the basic framework for the discussions on topic.



Source: Bal and Gundry (1999)

Figure 1 Model for effective virtual team working

VIRTUAL TEAM WORKING: TECHNOLOGY POINT OF VIEW

Selection: Simple transmission of information from point A to point B is not enough; the virtual environment presents significant challenges to effective communication [8]. 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 [86].

Table 5 matrix assist the virtual team facilitator choose the appropriate technology based upon the purpose of the meeting.

Location: Virtual team allow 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[74]. Table 6 illustrates the relationship between tool, time and space in virtual teams.

Table 5 Tools for virtual teams (Adopted from Thissen et al. [87])

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 onsite • 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"> • Numerous 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

Table 6 Time /Space matrix (Adapted from Bouchard and Cassivi [88])

	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

Training: The results of Anderson et al. [80] systematic lab study confirm many of the observations include explicit preparation and training for virtual teams as a way of working collaboratively. Fuller et al., [42] results indicate that in the case of computer collective efficacy, computer training related to more advanced skills sets may be useful in building virtual team efficacy. The Hertel et al. [20] suggested that the training led to increased cohesiveness and team satisfaction.

Security: Virtual team working involves exchange and manipulation of sensitive information and data through the Internet, therefore security is always an important issue of concern [84]. Team leaders should identify the special technological and security level needs of the virtual team and their team members [89].

VIRTUAL TEAM WORKING: PEOPLE POINT OF VIEW

Team selection: Team selection is a key factor which differentiates successful teams from unsuccessful ones. The selection of partners greatly affects mutual trust, knowledge sharing, and performance [90]. Virtual teams can be designed to include the people most suited for a particular project [74]. Virtual team leaders rather than need to make sure the project is clearly defined, outcome priorities are established, and that a supportive team climate, need to select members with necessary skills [89].

Reward structure: The development of a fair and motivating reward system is another important issue at the beginning of virtual teamwork [20, 91]. Virtual team performance must be recognized and rewarded [85]. Lurey and Raisinghani [86] 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.

Meeting training: Comparing teams with little and extensive training, Bal and Gundry [85] observed 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 require some different types of training to ordinary teams. The training includes self-managing skills, communication and meeting training, project management skills, technology training, etc. [84].

Specify 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 [20]. Such an approach changes the role of a team manager from traditional controlling into more coaching and moderating functions [92].

VIRTUAL TEAM WORKING: PROCESS POINT OF VIEW

Processes represent the ongoing interaction between group members. It refers to the interdependent actions carried out by members, which transforms inputs to outputs [66].



Alignment: is the degree to which the interests and actions of each employee support the clearly stated and communicated key goals of the organization. The company's processes need to be re-aligned with the capabilities of virtual teams as opposed to face to face teams. This involves an understanding of the virtual team processes and the existing processes [85]. 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 [36]. Enabling flexible work almost always requires major changes in technology. Literature has shown few organizations are making effective use of good collaborative technologies that are readily available.

Meeting structure: Proximity enables team members to engage in informal work [63]. Virtual team members are more likely to treat one another formally and less likely to reciprocate requests from one another [14]. Shin [17] 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 team [93]. The physical absence of a formal leader exacerbates lack of extrinsic motivation [92]. In virtual teams that rarely meet face-to-face, team leaders often have no choice but to implement a formal team structure.

Performance measurement: Work on the performance of virtual teams by Kirkman and Rosen, et al. [25] demonstrates a positive correlation between empowerment and virtual team performance. High-performance teams are distinguished by passionate dedication to goals, identification and emotional bonding among team members, and a balance between unity and respect for individual differences. Staples and Webster [94] showed that the relationship between knowledge sharing and team performance was much weaker for semi-virtual teams than for traditional face-to-face teams or purely virtual teams.

Team facilitation: Virtual team members must have clear roles and accountabilities. Lack of visibility may cause virtual team members to feel less accountable for results, therefore explicit facilitation of teamwork takes on heightened importance for virtual teams. Temporal coordination mechanisms such as scheduling deadlines and coordinating the pace of effort are recommended to increase vigilance and accountability [93]. Very little empirical research had been conducted on virtual teams and almost nothing on virtual team facilitation [95] so future research on Team facilitation is needed. Table 7 lists the communication channels that the facilitators may use and some of the factors that influenced their use [96].

Table 7 Available communication channels and factors influencing their selection and use (source Pauleen and Yoong [96])

Communication channels	Primary conditions influencing selection and use
Face-to-face	Project complexity and time-frames Distance from team members Culture of team members Security requirements Financial resources/availability
Letter	Project time-frames Culture of team members
Telephone	Project time-frames Distance from team members Financial resources
e-mail	Project time-frames Distance from team members Financial resources Knowledge management systems Availability
Internet-based channels Desktop video conferencing Intranets	Project time-frames Distance from team members Financial resources



Text chat	Training Knowledge management systems Availability and compatibility
-----------	--

VIRTUALITY AND INNOVATION

Innovation plays a central role in economic development, at regional and national level [97]. Innovation is something new that was introduced in an environment, i.e., a new product, a new way of realizing a process, etc. [37]. Therefore, an innovation represents the final stage of a development process, representing the final result achieved and implemented successfully. Innovation correlated with the performance of firms and the new products and process improvements partially account for the higher sales and employment growth as well as the higher profit margins [98]. Howells et al. [99] state that the shift from serial to simultaneous and parallel working in innovation has become more commonplace and Blomqvist et al. [100] emphasized collaboration is as a meta-capability for innovation. When innovation is autonomous, the decentralized virtual team can manage the development and commercialization tasks quite well [101]. In virtual teams innovation behavior can be stimulated by using reciprocal IT tools (like document sharing), coordination by trust (not by output) and high job demands [6].

CONCLUSION

Strong business and social pressures are driving the adoption of virtual team working. This paper with a comprehensive review of literature and related resources covering the topic along with Bal and Teo [84], find that success in implementing virtual team working is more about processes and people than about technology. Organizations are often naive about the advantages, problems and disadvantages of virtual team working. Virtual teams offer many benefits to organizations striving to handle a more demanding work environment, but also present many challenges and potential pitfalls. With comparing Table 3, with Table 4 it is clearly obvious that advantages of utilize virtual teams are far from its disadvantages so dealing with it can bring new findings. Virtual teams are a new and exciting work form with many fascinating opportunities. Due to these opportunities, virtual teamwork becomes increasingly popular in organizations.

This paper has identified and extended 12 key factors that need to be considered, and describes a methodology focused on supporting virtual team working, with a new approach that has not been specifically addressed in the existing literature. 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. It is apparent from the literature review that significant differences are between virtual teams and co-located teams hence manager of virtual teams should not ignore these differences at their own peril. Suggestions for the training of remote managers and virtual team development can be found in the literature. Manager of virtual team should overcome the managing conflict, cultural and functional diversity in virtual teams and mistrust among the team members. The illustrated model enables consideration of known indicators of effectiveness for the design and management of virtual teams.

We need to focus here on the dynamic nature of both innovation processes and virtual team processes. Our study design did not fully acknowledge this fact. Future research would now seem to be essential for developing a comprehensive study, combining literature survey with case study in different size of companies (e.g. multinational companies and small and medium enterprises) and various type of activities (e.g. research and development and new product development). Such a study would provide an assessing What patterns, practices, or types of activities must virtual teams carry out to achieve effectiveness in the competitive environment?, How such teams should be managed? What types of process structure and technology support should be provided for facilitating such teams?, What different Methods of virtual team are uses today and how effective are they?,

What benefits and problems arise as a consequence of the creation of virtual team? and How to make the transition from a more traditional team structure to the more distributed team structure?. These questions and many other practical questions wait for future empirical investigation.

References:

1. von Zedtwitz, M., O. Gassmann, and R. Boutellier, *Organizing global R&D: challenges and dilemmas*. Journal of International Management, 2004. **10**(1): p. 21-49.
2. OECD, *OECD Proceedings Enhancing SME Competitiveness, The OECD Bologna Ministerial Conference, in Enterprise, Industry and Services*. 2001, OECD - Organisation for Economic Co-operation and Development. p. I-245.
3. Stough, S., S. Eom, and J. Buckenmyer, *Virtual teaming: a strategy for moving your organization into the new millennium*. Industrial Management & Data Systems, 2000. **100**(8): p. 370 - 378.
4. Kirkman, B.L., et al., *Five challenges to virtual team success: lessons from Sabre Inc*. Academy of Management Executive, 2002. **16**(3): p. 67-79.
5. Martins, L.L., L.L. Gilson, and M.T. Maynard, *Virtual teams: What do we know and where do we go from here?* Journal of Management, 2004. **30**(6): p. 805-835.
6. Leede, J.d., et al., *Conditions for innovation behaviour of virtual team members: a 'high-road' for internationally dispersed virtual teams*. The Journal of E-working 2008. **2**(1): p. 22-46.
7. Kirkman, B.L., C.B. Gibson, and D.L. Shapiro, "Exporting" teams enhancing the implementation and effectiveness of work teams in global affiliates Organizational Dynamics 2001. **30**(1): p. 12-29.
8. Walvoord, A.A.G., et al., *Empowering followers in virtual teams: Guiding principles from theory and practice*", *Computers in Human Behavior (article in press)*. 2008.
9. Cascio, W.F., *Managing a virtual workplace*. The Academy of Management Executive, 2000. **14**(3): p. 81-90.
10. Johnson, P., V. Heimann, and K. O'Neill, *The "wonderland" of virtual teams*. Journal of Workplace Learning, 2001. **13**(1): p. 24 - 30.
11. Bal, J. and P.K. Teo, *Implementing virtual teamworking. Part 1: a literature review of best practice*. Logistics Information Management, 2001. **13**(6): p. 346 - 352.
12. Lee-Kelley, L. and T. Sankey, *Global virtual teams for value creation and project success: A case study*. International Journal of Project Management 2008. **26**: p. 51-62.
13. Paul, S., et al. *Understanding Conflict in Virtual Teams: An Experimental Investigation using Content Analysis*. in *38th Hawaii International Conference on System Sciences*. 2005 Hawaii.
14. Wong, S.S. and R.M. Burton, *Virtual Teams: What are their Characteristics, and Impact on Team Performance?* Computational & Mathematical Organization Theory, 2000. **6**(4): p. 339-360.
15. Gassmann, O. and M. Von Zedtwitz, *Trends and determinants of managing virtual R&D teams*. R&D Management 2003. **33**(3): p. 243-262.
16. Dafoulas, G. and L. Macaulay, *Investigating Cultural Differences in Virtual Software Teams*. The Electronic Journal of Information Systems in Developing Countries (EJISDC), 2002. **7**(4): p. 1-14.
17. Shin, Y., *Conflict Resolution in Virtual Teams*. Organizational Dynamics, 2005. **34**(4): p. 331-345.
18. Nemiro, J.E., *The Creative Process in Virtual Teams* Creativity Research Journal, 2002. **14**(1): p. 69 - 83.
19. Peters, L.M. and C.C. Manz, *Identifying antecedents of virtual team collaboration*. Team Performance Management, 2007. **13**(3/4): p. 117-129.
20. Hertel, G.T., S. Geister, and U. Konradt, *Managing virtual teams: A review of current empirical research*. Human Resource Management Review, 2005. **15**: p. 69-95.
21. Rezgui, Y., *Exploring virtual team-working effectiveness in the construction sector*. Interacting with Computers, 2007. **19**: p. 96-112.
22. Precup, L., et al., *Virtual team environment for collaborative research projects*. International Journal of Innovation and Learning, 2006. **3**(1): p. 77 - 94
23. Cascio, W.F. and S. Shurygailo, *E-Leadership and Virtual Teams*. Organizational Dynamics, 2003. **31**(4): p. 362-376.
24. Leenders, R.T.A.J., J.M.L.V. Engelen, and J. Kratzer, *Virtuality, communication, and new product team creativity: a social network perspective*. Journal of Engineering and Technology Management, 2003. **20**: p. 69-92.



25. Kirkman, B.L., et al., *THE IMPACT OF TEAM EMPOWERMENT ON VIRTUAL TEAM PERFORMANCE: THE MODERATING ROLE OF FACE-TO-FACE INTERACTION*. Academy of Management Journal, 2004. **47**(2): p. 175-192.
26. May, A. and C. Carter, *A case study of virtual team working in the European automotive industry*. International Journal of Industrial Ergonomics, 2001. **27**: p. 171-186.
27. Martinez-Sanchez, A., et al., *Teleworking and new product development*. European Journal of Innovation Management, 2006. **9**(2): p. 202-214.
28. McDonough, E.F., K.B. Kahn, and G. Barczak, *An investigation of the use of global, virtual, and collocated new product development teams*. The Journal of Product Innovation Management, 2001. **18**(2): p. 110-120.
29. Ozer, M., *Information Technology and New Product Development Opportunities and Pitfalls*. Industrial Marketing Management 2000. **29**(5): p. 387-396.
30. Taifi, N., *Organizational Collaborative Model of Small and Medium Enterprises in the Extended Enterprise Era: Lessons to Learn from a Large Automotive Company and its dealers' Network.*, in *Proceedings of the 2nd PROLEARN Doctoral Consortium on Technology Enhanced Learning, in the 2nd European Conference on Technology Enhanced Learning*. 2007, CEUR Workshop Proceedings.: Crete, Greece.
31. Choi, Y., K. Kim, and C. Kim, *A design chain collaboration framework using reference models*. The International Journal of Advanced Manufacturing Technology, 2005. **26**(1): p. 183-190.
32. Vaccaro, A., F. Veloso, and S. Brusoni, *The Impact of Virtual Technologies on Organizational Knowledge Creation: An Empirical Study*, in *Hawaii International Conference on System Sciences*. 2008, Proceedings of the 41st Annual Publication p. 352-352.
33. Stoker, J.I., et al., *Leadership and innovation: relations between leadership, individual characteristics and the functioning of R&D teams*. The International Journal of Human Resource Management, 2001. **12**(7): p. 1141 – 1151.
34. Munkvold, B.E. and I. Zigur, *Process and technology challenges in swift-starting virtual teams*. Information & Management, 2007. **44**(3): p. 287-299.
35. Gassmann, O. and M. Von Zedtwitz, *Innovation Processes in Transnational Corporations*. International Handbook of Innovation, ed. L.V. Shavinina. 2003: Elsevier Science Ltd.
36. Rosen, B., S. Furst, and R. Blackburn, *Overcoming Barriers to Knowledge Sharing in Virtual Teams*. Organizational Dynamics, 2007. **36**(3): p. 259-273.
37. Sorli, M., et al., *Managing product/process knowledge in the concurrent/simultaneous enterprise environment*. Robotics and Computer-Integrated Manufacturing, 2006. **22**: p. 399-408.
38. Beranek, P.M. and B. Martz, *Making virtual teams more effective: improving relational links*. Team Performance Management, 2005. **11**(5-6): p. 200-213.
39. Piccoli, G., A. Powell, and B. Ives, *Virtual teams: team control structure, work processes, and team effectiveness*. Information Technology & People, 2004. **17**(4): p. 359 - 379.
40. Rice, D.J., et al., *Improving the Effectiveness of Virtual Teams by Adapting Team Processes*. Computer Supported Cooperative Work, 2007. **16**: p. 567-594.
41. Bergiel, J.B., E.B. Bergiel, and P.W. Balsmeier, *Nature of virtual teams: a summary of their advantages and disadvantages*. Management Research News, 2008. **31**(2): p. 99-110.
42. Fuller, M.A., A.M. HARDIN, and R.M. DAVIDSON, *Efficacy in Technology-Mediated Distributed Team* Journal of Management Information Systems, 2006. **23**(3): p. 209-235.
43. Kankanhalli, A., B.C.Y. Tan, and K.-K. Wei, *Conflict and Performance in Global Virtual Teams*. Journal of Management Information Systems, 2006. **23**(3): p. 237-274.
44. Prasad, K. and K.B. Akhilesh, *Global virtual teams: what impacts their design and performance?* Team Performance Management, 2002 **8**(5/6): p. 102 - 112.
45. Olson-Buchanan, J.B., et al., *Utilizing virtual teams in a management principles course*. Education + Training, 2007. **49**(5): p. 408-423.
46. Boudreau, M.-C., et al., *Going Global: Using Information Technology to Advance the Competitiveness Of the Virtual Transnational Organization*. Academy of Management Executive, 1998. **12**(4): p. 120-128.
47. Biuk-Aghai, R.P., *Patterns of Virtual Collaboration*, in *Faculty of Information Technology*. 2003, University of Technology: Sydney. p. 291.

48. Liu, B. and S. Liu, *Value Chain Coordination with Contracts for Virtual R&D Alliance Towards Service*, in *The 3rd IEEE International Conference on Wireless Communications, Networking and Mobile Computing, WiCom 2007*. 2007, IEEE Xplore: Shanghai, China. p. 3367-3370.
49. Lipnack, J. and J. Stamps, *Why The Way to Work*, in *Virtual Teams: People Working across Boundaries with Technology*. 2000, John Wiley & Sons: New York. p. 1-25.
50. Rabelo, L. and T.H.S. Jr., *Sustaining growth in the modern enterprise: A case study*. *Journal of Engineering and Technology Management JET-M*, 2005. **22** p. 274-290.
51. Chen, T.-Y., *Knowledge sharing in virtual enterprises via an ontology-based access control approach*. *Computers in Industry*, 2008. **Article In press**: p. No of Pages 18.
52. Shachaf, P., *Cultural diversity and information and communication technology impacts on global virtual teams: An exploratory study*. *Information & Management*, 2008 **45**(2): p. 131-142.
53. Kusar, J., et al., *How to reduce new product development time*. *Robotics and Computer-Integrated Manufacturing* 2004. **20**: p. 1-15.
54. Ge, Z. and Q. Hu, *Collaboration in R&D activities: Firm-specific decisions*. *European Journal of Operational Research* 2008. **185**: p. 864-883.
55. Mulebeke, J.A.W. and L. Zheng, *Incorporating integrated product development with technology road mapping for dynamism and innovation*. *International Journal of Product Development* 2006 **3**(1): p. 56 - 76.
56. Guniš, A., J. Šišlák, and Š. Valčuha, *Implementation Of Collaboration Model Within SME's*, in *Digital Enterprise Technology-Perspectives and Future Challenges*, P.F. Cunha and P.G. Maropoulos, Editors. 2007, Springer US. p. 377-384
57. Zhang, S., W. Shen, and H. Ghenniwa, *A review of Internet-based product information sharing and visualization*. *Computers in Industry* 2004. **54**(1): p. 1-15.
58. Sridhar, V., et al., *Analyzing Factors that Affect Performance of Global Virtual Teams*, in *Second International Conference on Management of Globally Distributed Work 2007*: Indian Institute of Management Bangalore, India. p. 159-169.
59. Cummings, J.L. and B.S. Teng, *Transferring R&D knowledge: the key factors affecting knowledge transfer success*. *Journal of Engineering Technology Management*, 2003(20): p. 39-68.
60. Schmidt, J.B., M.M. Montoya-Weiss, and A.P. Massey, *New product development decision-making effectiveness: Comparing individuals, face-to-face teams, and virtual teams*. *Decision Sciences*, 2001. **32**(4): p. 1-26.
61. Criscuolo, P., *On the road again: Researcher mobility inside the R&D network*. *Research Policy*, 2005. **34**: p. 1350-1365
62. Samarah, I., S. Paul, and S. Tadisina. *Collaboration Technology Support for Knowledge Conversion in Virtual Teams: A Theoretical Perspective*. in *40th Hawaii International Conference on System Sciences (HICSS)*. 2007. Hawaii.
63. Furst, S.A., et al., *Managing the life cycle of virtual teams*. *Academy of Management Executive*, 2004. **18**(2): p. 6-20.
64. Badrinayanan, V. and D.B. Arnett, *Effective virtual new product development teams: an integrated framework*. *Journal of Business & Industrial Marketing*, 2008. **23**(4): p. 242-248.
65. Boutellier, R., et al., *Management of dispersed product development teams: The role of information technologies*. *R&D Management*, 1998. **28**(13-25).
66. Gaudes, A., et al., *A Framework for Constructing Effective Virtual Teams* *The Journal of E-working* 2007 **1**(2): p. 83-97
67. Ortiz de Guinea, A., J. Webster, and S. Staples. *A Meta-Analysis of the Virtual Teams Literature*. in *Symposium on High Performance Professional Teams Industrial Relations Centre*. 2005. School of Policy Studies, Queen's University, Kingston, Canada.
68. Shachaf, P. and N. Hara, *Team Effectiveness in Virtual Environments: An Ecological Approach*, in *Teaching and Learning with Virtual Teams*, P.a.G. Ferris, S., Editor. 2005, Idea Group Publishing. p. 83-108.
69. Pawar, K.S. and S. Sharifi, *Physical or virtual team collocation: Does it matter?* *International Journal of Production Economics* 1997. **52**: p. 283-290.
70. Baskerville, R. and J. Nandhakumar, *Activating and Perpetuating Virtual Teams: Now That We're Mobile, Where Do We Go?* *IEEE Transactions on Professional Communication*, 2007. **50**(1): p. 17 - 34



71. Qureshi, S. and D. Vogel, *Adaptiveness in Virtual Teams: Organisational Challenges and Research Directions*. Group Decision and Negotiation 2001. **10**(1): p. 27-46
72. Ocker, R.J. and J. Fjermestad, *Communication differences in virtual design teams: findings from a multi-method analysis of high and low performing experimental teams*. The DATA BASE for Advances in Information Systems, 2008. **39**(1): p. 51-67.
73. Griffith, T.L., J.E. Sawyer, and M.A. Neale, *Virtualness and Knowledge in Teams: Managing the Love Triangle in Organizations, Individuals, and Information Technology*. MIS Quarterly, 2003. **27**(2): p. 265-287.
74. Bell, B.S. and S.W.J. Kozlowski, *A Typology of Virtual Teams: Implications for Effective Leadership*. Group and Organization Management, 2002. **27**(1): p. 14-49.
75. Pawar, K.S. and S. Sharifi, *Virtual collocation of design teams: coordinating for speed*. International Journal of Agile Management Systems, 2000. **2**(2): p. 104 - 113.
76. Shachaf, P., *Bridging cultural diversity through e-mail*. Journal of Global Information Technology Management, 2005. **8**(2): p. 46-60.
77. Jacobsa, J., et al., *Exploring defect causes in products developed by virtual teams* Information and Software Technology, 2005. **47**(6): p. 399-410.
78. Paul, S., et al. *Understanding Conflict in Virtual Teams: An Experimental Investigation using Content Analysis*. in *38th Hawaii International Conference on System Sciences*. 2005 Hawaii.
79. Poehler, L. and T. Schumacher, *The Virtual Team Challenge: Is It Time for Training?*, in *PICMET 2007 2007* Portland, Oregon - USA p. 2205-2211.
80. Anderson, A.H., et al., *Virtual team meetings: An analysis of communication and context*. Computers in Human Behavior, 2007. **23**: p. 2558–2580.
81. Jarvenpaa, S.L. and D.E. Leidner, *Communication and Trust in Global Virtual Teams*. Organization Science 1999. **10**(6): p. 791 - 815
82. Lin, C., C. Standing, and Y.-C. Liu, *A model to develop effective virtual teams*. Decision Support Systems, 2008. **45**(4): p. 1031-1045.
83. Malhotra, A. and A. Majchrzak, *Enabling knowledge creation in far-flung teams: best practices for IT support and knowledge sharing*. Journal of Knowledge Management, 2004. **8**(4): p. 75 - 88.
84. Bal, J. and P.K. Teo, *Implementing virtual teamworking: Part 3 – a methodology for introducing virtual teamworking*. Logistics Information Management, 2001. **14**(4): p. 276 - 292.
85. Bal, J. and J. Gundry, *Virtual teaming in the automotive supply chain*. Team Performance Management, 1999. **5**(6): p. 174 - 193.
86. Lurey, J.S. and M.S. Raisinghani, *An empirical study of best practices in virtual teams* Information & Management, 2001. **38**(8): p. 523-544.
87. Thissen, M.R., et al., *Communication tools for distributed software development teams*, in *Proceedings of the 2007 ACM SIGMIS CPR conference on Computer personnel research: The global information technology workforce*. 2007, ACM: St. Louis, Missouri, USA.
88. Bouchard, L. and L. Cassivi, *Assessment of a Web-groupware technology for virtual teams*, in *IAMOT 2004*. 2004: Washington, D.C.
89. Hunsaker, P.L. and J.S. Hunsaker, *Virtual teams: a leader's guide*. Team Performance Management, 2008. **14**(1/2): p. 86-101.
90. Wi, H., et al., *Modeling and analysis of project team formation factors in a project-oriented virtual organization (ProVO)*. Expert Systems with Applications 2008. **Article in Press**.
91. Bal, J. and P.K. Teo, *Implementing virtual teamworking: Part 2 - a literature review*. Logistics Information Management, 2001 **14**(3): p. 208 - 222.
92. Kayworth, T.R. and D.E. Leidner, *Leadership Effectiveness in Global Virtual Teams* Management Information Systems, 2002. **18**(3): p. 7 - 40
93. Massey, A.P., M.M. Montoya-Weiss, and H. Yu-Ting, *Because Time Matters: Temporal Coordination in Global Virtual Project Teams*. Journal of Management Information Systems, 2003. **19**(4): p. 129-155.
94. Staples, D.S. and J. Webster, *Exploring the effects of trust, task interdependence and virtualness on knowledge sharing in teams*. Information Systems Journal, 2008. **18**(6): p. 617-640.
95. Pauleen, D.J. and P. Yoong, *Studying Human-Centered IT Innovation Using a Grounded Action Learning Approach*. The Qualitative Report, 2004. **9**(1): p. 137-160.



96. Pauleen, D.J. and P. Yoong, *Relationship building and the use of ICT in boundary-crossing virtual teams: a facilitator's perspective*. Journal of Information Technology, 2001. **16**(4): p. 205-220.
97. Haga, T., *Action research and innovation in networks, dilemmas and challenges: two cases* AI & Society 2005. **19**(4): p. 362-383.
98. Dickson, K.E. and A. Hadjimanolis, *Innovation and networking amongst small manufacturing firms in Cyprus*. International Journal of Entrepreneurial Behavior & Research, 1998. **4**(1): p. 5-17.
99. Howells, J., A. James, and K. Malik, *The sourcing of technological knowledge: distributed innovation processes and dynamic change*. R&D Management, 2003. **33**(4): p. 395-409.
100. Blomqvist, K., et al., *Towards networked R&D management: the R&D approach of Sonera Corporation as an example*. R&D Management, 2004. **34**(5): p. 591-603.
101. Chesbrough, H.W. and D.J. Teece, *Organizing for Innovation: When Is Virtual Virtuous?* Harvard Business Review Article, 2002. **August** p. 127-135.