INTERNATIONAL ENGINEERING AND PRODUCT DESIGN EDUCATION CONFERENCE
2-3 SEPTEMBER 2004 DELFT THE NETHERLANDS

WORKING COLLABORATIVELY IN TODAYS GLOBAL ENVIRONMENT: A GLOBAL PRODUCT DEVELOPMENT COURSE?

Erik Bohemia

ABSTRACT
Literature proposes that manufacturing industry is adopting agile manufacturing principles. One of which is adoption of virtual partnerships, which requires staff to have skills to be able to operate in this type environment. Therefore, the purpose of this paper is to stimulate a discussion on how the academy can assist their graduates to develop skills which would enable them to participate on virtual product development teams.

Keywords: Virtual; Product Development; Global; Physically Distributed Design Teams

1 INTRODUCTION

A review of the advanced manufacturing literature has identified that the increased globalisation of markets and manufacturing is forcing organisations to increase flexibility and at the same time reduce product development time, which has become a critical measure of business performance [5]. In order to increase the speed and quality of the design process, organisations are moving away from sequential product development process (over-the-wall) to implementing concurrent engineering which utilises cross-functional work teams [3, 8, 15, 23, 30, 34]. It is proposed that the use of cross-functional teams promotes communication, collaboration and integration between project team members during the design process [6, 7, 29]. The literature on concurrent engineering highlights the importance of collocating the cross-functional team members to foster formal and informal communication exchange amongst the project team members [1, 22, 29].

However, the literature also points out that rapid global change in manufacturing industries, increased cost and complexity of new product development, and advancement in information technologies (IT) and manufacturing technologies is leading organisations to experiment in the co-development of products with partners in virtual settings [2, 14, 16, 17], see Figure 1.

2 AGILE MANUFACTURING

In addition, in 1991, the Lehigh University published a report on the global competitive environment faced by U.S. manufacturers [21]. The report coined a new term *'agile manufacturing'* and the *'Virtual Company'* [13, 20, 23, 28]. Whitney et al. [33] identified four underpinning principles that are used in agile manufacturing; delivery value to the customer, being ready for change, valuing human knowledge and skills, and forming virtual partnerships. It is argued that agile manufacturing will bring to organisations a greater flexibility [24] and even shorter lead-time to market and

increased focus on customer satisfaction [10, 20, 32]. To accomplish this, it is important to create faster and greater partnerships and networks of companies by creating 'Virtual Companies'. It is suggested that this 'web' of companies can improve its performance if parties take pro-active steps during the early design stages to manage this web as a complete system [10, 33].

However, the current research indicates that most companies are facing difficulties with managing new product development processes especially as many of the tasks can now be undertaken across the globe [11]. This is compounded by the fact that very little is known about issues surrounding virtual product development processes [2].

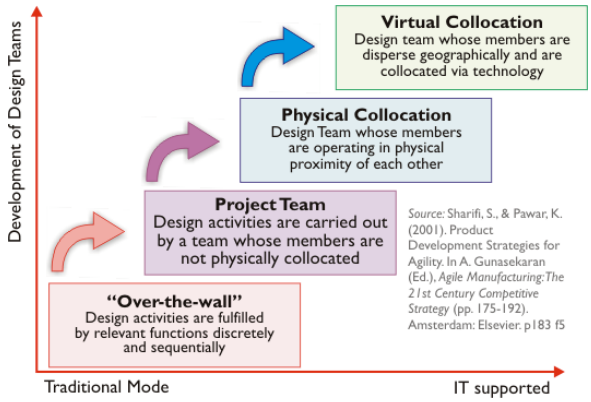

Figure 1 Patterns of the Formation of Design Teams, [27, p. 183]

As stated previously, it is proposed that having team members physically collocated plays an important part in accelerating information exchange and integration amongst various functions [22, 29]. The literature indicates that as physical distance of project team members increases, the frequency of communication amongst these project team members decreases [9, 31], see Figure 2. Therefore it is suggested that collocation provides a number of benefits to the project team members, such as allowing the project team members to conduct unscheduled/informal meetings, it also could foster faster communication cycles and shorter feedback [e.g. 22, 27], see Figure 3.

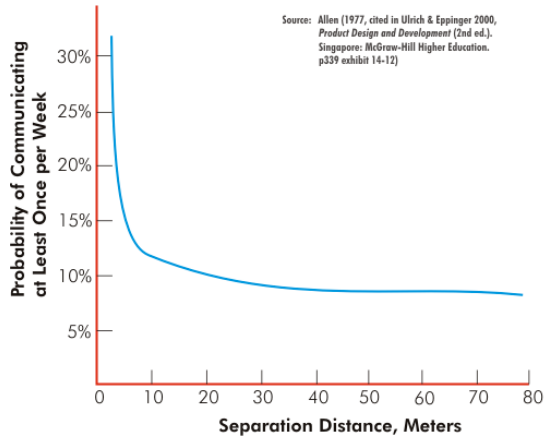

Figure 2 Communication frequency vs separation distance [Allen cited in 31, p. 339]

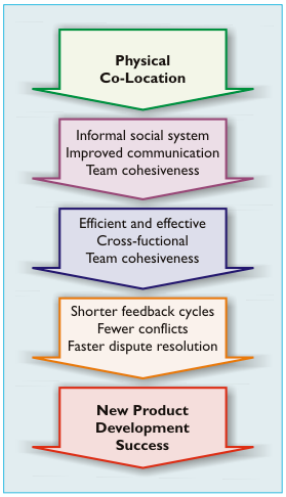

Figure 3 Benefits of Co-location [25, p. 63]

It is proposed that the use of virtual cross-functional product development teams and the new emphasis on speed and flexibility requires a new and different approach for managing new product development. Thus, organisations have to re-examine the way products are designed, manufactured and serviced [12, 26, 27, 36].
Working in virtual cross-functional teams and the use of concurrent engineering, require organisational members, including industrial designers and engineers, to have skill sets that enable them to operate successfully in this new setting [16, 18, 19, 35]. Sharifi and Pawar, proposed that the physical collocation differs from virtual collocation on a number of characteristics, see Table 1. Therefore, curriculum development in the higher education of industrial designers and engineers needs to take into account the changes in contemporary manufacturing organisations and provide students with skills sets for operating effectively in these newly developed settings [4, 5].

Table 1 A comparison of the typical characteristics of physical or virtual collocated design teams [27]

Physical Collocation	Characteristic	Virtual Collocation
Close	**Physical Proximity**	Remote
In small and medium sized companies with one or few sites	**Typical Use**	Multi-national and International organisations with different sites
Limited variety of cultures, since the team members may come from same company site	**Cultures**	Different people from different countries or sites, with a variety of experiences
Opportunity for sharing formal and informal information (ideas, dilemmas) between team members	**Information Exchange**	Limited opportunity to share informal information because of the dispersed location
Ample opportunity for face-to-face interactions	**Relationships**	Limited opportunity to interact and build relationships
An evolving common sense of purpose	**Purpose**	A directed common sense of purpose
Ample opportunity for sharing of resources (technical, human, financial)	**Resources**	Limited access to similar technical and non-technical resources
Fewer hiccups due to possible sharing of technical systems	**Technology**	Possible problems in terms of hardware, software and resources, due to variation in technical systems

Physical Collocation	Characteristic	Virtual Collocation
A higher sense of belonging within the team	**Working Environment**	Feeling of isolation, and frustration, and possible absence of sense of belonging
Availability of information at anytime to every member	**Accessing Information**	Limitation in time and space for accessing information
Greater visibility of the design work	**Transparency of design activities**	Lack of visibility of work being carried on by the group
Similarity of work method and employment	**Educational/Training background**	Differences in education, language, training, time orientation and expertise
A lower degree of empowerment and closer supervision	**Empowerment and Management of the team**	A higher degree of empowerment and delegated authority and looser control

3 WORKSHOP AIMS

The broad aim of this workshop is to start an initial discussion around a new program that could be introduced into academic curriculum with the objective of introducing students to global virtual teamwork environment. Students participating in this new program would gain experience on using distance communication techniques and would develop virtual teamwork skills, skills that are becoming increasingly important in new product development.

This discussion is aimed at identifying the issues and challenges that would have to be worked through prior to the implementation of such a program from the perspective design educators working in higher education.

Some of the opportunities that could come out of implementing and running this type of program may go beyond simple student learning. For example academic members would be also be exposed to global virtual teamwork and global virtual project management. This program could assist the participating institutions to develop a shared understanding of how to manage this type of program. It could also provide fertile ground for developing closer cross-institutional links which may lead to unexpected and exciting research avenues. For example, this new program could initiate a global collaborative research strategy/program that could aim to explore possible ways to develop and advance knowledge and expertise in virtual long-distance cross-disciplinary and cross-cultural product development projects, thus developing know-how which is increasingly needed within today's global industry. This could extend the members expert knowledge in the areas that need to be considered while generating and creating new designs and ultimately products, such as materials, cost, legal and environment factors, function, culture and market in a virtual product development environment. This would also assist the involved educational intuitions to incorporate this “know-how” in their educational programs, so that the graduates have the skills that are needed in “tomorrow’s” industry.

Challenges such as these would have to be overcome:

- **Timing:** Start of academic year and semester length differs from country to country
- **Level:** At what level the program should be introduced? What assumed prior skills should students already have?
- **Ownership:** Who owns the program?
- **Assessment:** What type of assessment would be suitable? What proportion should be team and individual based?

- **Resources:** What resources would be needed to run this program? Would a potential difference in the level of available resources at one intuition disadvantage its students?
- **Language barrier:** language proficiency could act as a barrier to successful communication in virtual settings
- **Academic staff skills:** What skills should they have to manage and participle in this type of program?

4 CONCLUSION

The paper has outlined changes that are currently taking place in the manufacturing industry such as the adoption of agile manufacturing principles that incorporate virtual product development teams. As a result of this change, it is becoming important for engineers and designers to develop skills which will enable them to participate effectively in virtual product development teams.

This means that educational intuitions need to explore ways to prepare their students for these new workplace practices. Therefore, it is proposed that one of the ways this trend can be addressed is to develop a new international program that would encourage students experience in using distance communication technologies and develop virtual teamwork skills.

This workshop has provided a forum for identifying key initial issues and for establishing a consortium that is interested in developing a global product development program.

REFERENCES

[1] Power of Ideas at Work: The Fall Protection Team; The EZ-35 Team; and The Elite Team Innovative Project Teams, Harvard Business School Management Productions in association with David Grubin Productions, Inc., Boston, US, 1994.

[2] Altenkirch, R., Aung, W., Cruz, B.C., Garside, J., Hinrichs, R., Johnson, W., Nieto, J., Roubicek, V., Thomas, G., Velez-Arocho, J., Wei, C.-H. and Zielinski, W. What We Must Do Together to Increase Quality and Productivity. in Aung, W., Hoffmann, M.H.W., Jern, N.W., King, R.W. and Ruiz , L.M.S. eds. Innovations 2003: World Innovations in Engineering Education and Research, Begell House Publishing, Arlington, VA, 2003, 1-12.

[3] Beckwith, D. Putting a hard edge on soft values: the higher order of cross-functional multidisciplinary teams. Design Management Journal, 5 (4). 1994, 11-16.

[4] Bohemia, E. Designer as integrator: reality or rhetoric? The Design Journal, 5 (2). 2002, 23-34.

[5] Bohemia, E., Development of distance communication and virtual teamwork skills through online-based teaching. Proceedings of International Conference on Engineering Education (ICEE), Valencia, Spain, 2003, ICEE.

[6] Clark, K.B. and Fujimoto, T. The power of product integrity. Harvard Business Review, 68 (6). 1990, 107-118.

[7] Clark, K.B. and Fujimoto, T. Product Development Strategy. Harvard Business School Press, Boston, Massachusetts, US, 1991.

[8] Department of Industrial Relations and The Manufacturing Council. International Best Practice: Report of the Overseas Study Mission, Commonwealth of Australia, Canberra, ACT, Australia, 1992, 46.

[9] Farshchian, B.A. Integrating geographically distributed development teams

through increased product awareness. Information Systems, 26. 2001, 123–141.
[10] Fine, C. Fast and Flexible design and Manufacturing Systems for Automotive and Sheet Metal Parts, MIT/Lehigh, 1994, 13.
[11] Freeze, K.J. Digital Equipment Corporation: The VT320 Video Text Terminal, Design Management Institute Press, Boston, MA, US, 1991, 25.
[12] Gerwin, D. and Susman, G. Special Issue on Concurrent Engineering. IEEE Transactions on Engineering Management, 43 (2). 1996, 118-123.
[13] Gunasekaran, A. (ed.), Agile Manufacturing: The 21st Century Competitive Strategy. Elsevier, Amsterdam, 2001.
[14] Gunasekaran, A. An integrated product development-quality management system for manufacturing The TQM Magazine, 1998, 115-123.
[15] Hsiao, S.-W. A concurrent engineering based method for developing a baby carriage. International Journal of Advanced Manufacturing Technology, 12. 1996, 455-462.
[16] Larsen, K.R.T. and McInerney, C.R. Preparing to work in the virtual organization. Information & Management, 39. 2002, 445-456.
[17] Lau, H.C.W. and Wong, E.T.T. Application of Information Technology in Agile Manufacturing. in Gunasekaran, A. ed. Agile Manufacturing: The 21st Century Competitive Strategy, Elsevier, Amsterdam, 2001, 205-227.
[18] Maccoby, M. Building cross-functional capability: what it really takes. Research • Technology Management, 42 (3). 1999, 56-58.
[19] Maccoby, M. Creating network competence. Research • Technology Management, 43 (3). 2000, 59-60.
[20] Martin, J. Cybercorp: The New Business Revolution. American Management Association, New York, NY, US, 1996.
[21] Nagel, R., Dove, R., Goldman, S. and Preiss, K. 21st Century Manufacturing Strategy: Volume 1 and Volume 2, Iacocca Institute, Lehigh University, Bethlehem, PA, US, 1988.
[22] Pawar, K.S., Menon, U. and Riedel, J.C.K.H. Time to Market. Integrated Manufacturing Systems, 5 (1). 1994, 14-22.
[23] Port, O. Moving past the assembly line: agile manufacturing systems may bring a U.S. revival Business Week, 1992, 177-180.
[24] Prasad, B. A method for measuring total value towards designing goods and services. The TQM Magazine, 10 (4). 1998, 258-275.
[25] Rafii, F. and Perkins, S. Cross-Functional Integration: Moving Beyond Physical Co-location. Design Management Journal, 6 (3). 1995, 62-68.
[26] Randhawa, S.U. and Burhanuddin, S. Concurrent Product/Process Development. in Wang, B. ed. Concurrent Design of Products, Manufacturing Processes and Systems, Gordon and Breach Science Publishers, Amsterdam, Netherlands, 1998, 1-18.
[27] Sharifi, S. and Pawar, K. Product Development Strategies for Agility. in Gunasekaran, A. ed. Agile Manufacturing: The 21st Century Competitive Strategy, Elsevier, Amsterdam, 2001, 175-192.
[28] Sheridan, J.H. Agile manufacturing: stepping beyond lean production. Industry Week, 242 (8). 1993, 30-46.
[29] Song, M.X., Neeley, S.M. and Yuzhen, Z. Managing R&D-Marketing integration in the new product development process. Industrial Marketing Management, 25. 1996, 545-553.
[30] The Warren Centre for Advanced Engineering, Lawrence, P., Barlow, W., Conrad,

T., Denham, P., Quilter, B., Tuchfeld, J., Ward, R., Warner, F., Waterhouse, R., Pilditch, J., Bahnsen, U., Constable, J., Fitch, R., Goodman, P., Jackson, C., Livingston, A., McBurnie, E.T., Priestman, J. and Wiseman, G. Winning by Design: Technical Papers; The corporate role of Design in Australian Industry, The University of Sydney, Sydney, NSW, Australia, 1987, 190.

[31] Ulrich, K.T. and Eppinger, S.D. Product Design and Development. McGraw-Hill Higher Education, Singapore, 2000.

[32] Weimer, G. America 2006: manufacturing leader or loser? Controls and Systems, 39 (3). 1992, 66.

[33] Whitney, D., Anderson, M., Cadet, C., Fine, C., Grossard, D., Thornoton, A., Groover, M., Nagel, R., Ozsoy, T., Stenger, H., Anderson, M.A., Chang, M., Cunningham, T., Gutwald, P., Hardy, G., Lukaitis, J.J., Lee, D., Mantripragada, R., Pomponi, R., Soman, N., Baykan, E., Grief, P., Johnston, T., Kim, D., Marquette, D., Meixell, M. and Roth, S. Agile Pathfinders in the Aircraft and Automobile Industries - A Progress Report, Massachusetts Institute of Technology and Lehigh University, Cambridge, MA, US, 1995, 1-12.

[34] Womack, J.P., Jones, D.T. and Roos, D. The Machine That Changed the World. Rawson Associates, New York, NY, US, 1990.

[35] Wood, J., Chapman, J., Fromholtz, M., Morrison, V., Wallace, J., Zeffane, R., Schermerhorn, J., Hunt, J. and Osborn, R. Organisational Behaviour: A Global Perspective. John Wiley & Sons, Milton, Qld, 2004.

[36] Xue, D. and Dong, Z. Integrated Concurrent Design Using a Quantitative Intelligent System. in Wang, B. ed. Concurrent Design of Products, Manufacturing Processes and Systems, Gordon and Breach Science Publishers, Amsterdam, Netherlands, 1998, 99-132.

Contact Information:
Dr Erik Bohemia,
School of Engineering and Industrial Design,
University of Western Sydney,
Locked Bag 1797,
Penrith South Distribution Centre,
NSW 1797,
Australia.
Phone: +61 2 9852-5453
Email: e.bohemia@uws.edu.au