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Factors of collaborative working: A framework for a collaboration model

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ABSTRACT

The ability of organisations to support collaborative working environments is of increasing importance as they move towards more distributed ways of working. Despite the attention collaboration has received from a number of disparate fields, there is a lack of a unified understanding of the component factors of collaboration. As part of our work on a European Integrated Project, CoSpaces, collaboration and collaborative working and the factors which define it were examined through the literature and new empirical work with a number of partner user companies in the aerospace, automotive and construction sectors. This was to support development of a descriptive human factors model of collaboration – the CoSpaces Collaborative Working Model (CCWM). We identified seven main categories of factors involved in collaboration: Context, Support, Tasks, Interaction Processes, Teams, Individuals, and Overarching Factors, and summarised these in a framework which forms a basis for the model. We discuss supporting evidence for the factors which emerged from our fieldwork with user partners, and use of the model in activities such as collaboration readiness profiling.

1. Introduction

A critical success factor for any community – at work and outside work – is the extent to which it can coordinate itself to communicate and achieve common goals: in other words, to collaborate. A study by Frost & Sullivan (2006) sponsored by Verizon Business and Microsoft Corp. found that collaboration, an organisation's strategic orientation and market turbulence were the three main business performance drivers, and that of these collaboration had the most impact. It is becoming increasingly difficult for multinational corporations to maintain a competitive edge over global competitors; companies which can create and support collaboration between departments or with supply chain partner companies can best harness their distributed resources and expertise (Hansen and Nohria, 2004). Collaboration is a ubiquitous presence in our lives and is a constant feature of modern society; 'work is always immediately social in that the object and the subject, the end and the means, the motives and the needs, the implements and the competencies, are socially mediated' (Schmidt, 1991, p. 2).

The advantages to be gained from good collaboration will vary according to the type of business or company, but the benefits can include: increased profit through sharing expertise across business units or companies; reduction in costs through sharing best practices; improved decision making through sharing insights and knowledge; innovation through sharing ideas; and an improved ability to pursue goals that involve distributed units or companies (Hansen and Nohria, 2004). To achieve these advantages, however, an organisation should also be fully aware that there are potential disadvantages and barriers to collaboration, in order to manage them. These potential barriers are discussed later in the paper in the discussion section.

For a concept so widely used in everyday language there is a surprising lack of a clear understanding of what it is to collaborate, and of how best to support and improve collaborative working. Definitions are often tailored to a particular environment. However, common themes do emerge from the multitude of definitions and integrating some of these (e.g. Henneman et al., 1995; Mattessich and Monsey, 1992; Meads et al., 2005; Montiel-Overall, 2005; Schrage, 1990; Wilson, 2006) gives us a simple first working definition: Collaboration involves two or more people engaged in interaction with each other, within a single episode or series of episodes, working towards common goals.

This paper presents a first framework for a model of collaborative working. The context was a major European research project

Abbreviations: CAVE, Cave Automatic Virtual Environment; CWE, Collaborative Working Environments; CSCW, Computer Supported Cooperative Work; FAL, Final Assembly Line; DMU, Digital Mock-Up; OEM, Original Equipment Manufacturer.

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concerned with tools, systems and organisational structures for co-located, mobile and distributed collaborative engineering and design (see next section). Therefore the framework applies more to IT, engineering/design and collaborative work systems design, with less emphasis on (although not to the exclusion of) work on collaboration within military and aerospace settings, or local and political communities.

In the next section we summarise the project CoSpaces, and consequently the rationale behind the framework and model. After this we identify the main factors and sub-factors which structure the model, summarising the literature in terms of evidence for each factor. In order to reduce what was an enormous quantity of documentation to a form that can be summarised in a single paper, we do this within a structured tabular format. Whilst it is clearly beyond the scope of the original research work never mind this paper to explore all the factors empirically, in the section afterwards we provide some evidence from our own fieldwork with industrial user partners and systems developers. Finally the paper contains a discussion of the framework and model development and how they have been used in a variety of ways to date; we identify potential barriers to collaboration, discuss the limitations in our work and summarise work to date on verification.

2. CoSpaces Integrated Project

CoSpaces was a large European Commission funded Integrated Project developing innovative collaborative working solutions that are responsive to industrial needs. The project had many industrial, research and business partners from 12 European countries (see http://www.cospaces.org/downloads.htm). The focus was how advanced technologies (virtual, augmented, tele-immersive, mobile, and context aware) can be deployed to create collaborative engineering workspaces for planning, design, assembly, architecture, construction and maintenance activities in the aerospace, automotive and construction sectors. European companies are increasingly required to reduce lead-times for new products, improve their quality, and their customer and market responsiveness. To achieve these goals, the design and manufacture of products, buildings and systems are reliant upon dynamic, multidisciplinary teams, increasingly involving multiple organisations on a trans-national basis. The CoSpaces technical development was a re-configurable and dynamic software framework to support creation of Collaborative Working Environments (CWE) for teams involved in design and engineering tasks. Team members participate in decision making, view drawings, models and designs, propose or carry out modifications, and draw on reference materials, with systems and data access being adapted to collaborating partners' function, professional background, resource availability and current location. The collaborative working is thus across professional and organisational boundaries, in distributed, co-located and mobile workspaces. The CoSpaces technology should be adaptable to suit end users and their context, empowering engineers and designers as individuals and in their respective teams.

CoSpaces included a substantial, central and real human factors contribution, not always the case on large or small European ICT projects. The authors of this paper were the main human factors team on CoSpaces, with roles to act as intermediaries between potential end users and the developers, thus ensuring that the wider human and organisational issues associated with collaborative work were considered, and feasible user requirements and related evaluation protocols were provided. In fact, many of our user partners were well aware from their own experience that a lack of consideration of human factors was a barrier to collaboration and to the use of collaborative technologies. Early on we structured the involvement of the human factors specialists into the overall project in such a way as to be as supportive as possible of the technical development teams, acting as the representatives of the users and translators of their requirements so that the resultant systems could be implemented to benefit engineering and business performance. This was whilst ensuring that the needs for collaboration performance and systems usability were not swamped in the rush to produce advanced architectures and exciting tools (Wilson et al., 2009a).

In order that development of such complex systems could be carried out in time for deployment within the user companies well within the project's 42 month time frame, the project technical manager produced some very early visionary scenarios on digital video. These illustrated the designer, engineer or architect of the future, collaborating on tasks with colleagues around the world from wherever they were, including on the move, and sharing and working on digital design models and related logistic and development information. The visionary scenarios were used by the developers to help potential users to skip a technology generation in their imaginations, and to project a very different future of engineering and design modelling, simulation, planning, construction, production and communications. In parallel the human factors team wanted to ground the requirements for the CoSpaces systems in the end users' opinions and knowledge of collaboration today and likely needs for tomorrow, irrespective of the type of technology; or indeed even if no technical system was used – which led to interesting discussions with developers! To do this we used an iterative process of developing stories, scenarios, top level requirements, detailed requirements, evaluation protocols and measures (see Fig. 1).

To provide a foundation for this process the project required a model of collaborative working, the CoSpaces Collaborative Working Model (CCWM). The CCWM was not to be a formal computational model but was to be descriptive in that it identified and distinguished the various factors which make up or influence collaboration at work, built up in layers to group factors, and eventually to illustrate hypothesised or proven links between factors, including causative relationships. The model development was vital for seven inter-connected reasons:

1. As a basis to structure the system architecture
2. To support a user profiling tool built into the user interface
3. To enable a structured approach to scenario and user requirements development with respect to the act of collaboration (as distinct from engineering/design task performance)
4. To underpin iterative development, evaluation and implementation of CoSpaces systems within user partners and subsequently more widely
5. As a basis for development of a company collaboration readiness profiling tool
6. To fill a gap in the human factors literature with a structured descriptive model of the key factors of collaboration
7. To later predict and test interactions between sub-factors at one level or between levels of the model.

Before the CCWM could be developed we needed a framework of factors of collaborative work based on the state of the art and our own observations as these emerged, and it is this framework that we describe in this paper.

3. Framework of factors of collaborative work

CoSpaces technology will support collaboration at different levels, from small teams of individuals through larger project or enterprise groups and up to international arrangements between organisations. Therefore, our understanding of what it means to