Advanced Engineering Informatics 27 (2013) 580–597

Contents lists available at ScienceDirect

Advanced Engineering Informatics

journal homepage: www.elsevier.com/locate/aei

A Social Media framework to support Engineering Design Communication ☆,☆☆

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ARTICLE INFO

Article history:
Received 2 October 2012
Received in revised form 16 July 2013
Accepted 25 July 2013
Available online 23 August 2013

Keywords:
Engineering Design Communication (EDC)
Social Media (SM)
Knowledge sharing
Design rationale
Engineers network

ABSTRACT

Engineering Design Communication (EDC) is fundamental to almost all Engineering Design activities as it provides the ability for knowledge and information to be shared between engineers. It is part of 'what we do'. This communication contains a great deal of rationale relating to the evolution of Product Development and is essential for understanding 'why the product is the way it is'. The need to support EDC is becoming more important due to the fact that Product Development is becoming more distributed, multi-disciplinary and involving greater re-use of past designs. With the advent of Social Media (SM), it is argued that there is the technical capability to provide more effective support for EDC within a computer-mediated environment. In order to explore this potential, this paper defines the requirements for the effective support of EDC through an extensive review of the literature. It then discusses the suitability of a SM approach and then presents the theoretical foundations of a SM framework to support EDC.

1. Introduction

Engineering Design has been described as an ever more multidisciplinary and highly collaborative exercise, during which substantial levels of resources and information are shared within a highly contextualised environment [1]. Törlind and Larsson [2] describe Engineering Design as "fundamentally a socio-technical activity" where communication is an intrinsic part [3,4]. Based on the above description, this paper considers Engineering Design to be the activities undertaken by a network of engineers (henceforth referred to as the Engineers' Network) to develop a product. As a result of these activities, a large volume of documentation and numerous representations (i.e. artefacts) that pertain to (and define) the product is generated (for example, design models, mathematical analysis, physical prototypes and notes). All of these artefacts are interrelated to one another and therefore defined within this paper as the Product Artefact Network (PAN). Engineering Design Communication (EDC) is defined as the communication between engineers that pertain to the product and its development. Fig. 1 illustrates how this communication is a mediator between the Engineers' and Product Artefact Networks. It is the challenge of providing support for, and relating of EDC to both the Engineers' Network and PAN that is the focus of this paper.

1.1. The importance of EDC

Tenopir and King's [5, p. 30] review of communication patterns shows there is a consensus that engineers spend a significant proportion of time conversing with one another. Ellis and Haugan [6] and Wood and DeLoach [7] reveal that engineers make considerable use of communication channels to seek for information as colleagues are seen as easily accessible, trustworthy sources of information and are still preferred over search engine results [8,9]. A high proportion of communication is what is colloquially termed 'water-cooler conversations', as it is a quick informal exchange of knowledge and information between engineers [10–12]. Brown and Duguid [13] highlight that it is heavily relied upon to 'fill in the gaps' left by formal documentation and process manuals, as they can never fully account for every eventuality.

The relative level of EDC has also been shown to be indicative of progress being made and successful Product Development [14,15]. This is further supported by the engineering management literature showing that companies see communication as a critical success factor and that it has been shown to affect productivity and lead-time [16,17]. Dong [18] shows that almost all successful product design teams have high-levels of communication and the reasoning is that it supports the creation of a shared understanding between the engineers. Adler [19] and Daft and Lengel [20] describe how greater communication plays a key role in reducing uncertainty and what can be considered as 'needless' uncertainty as the information is available but the engineers are unable to access it, be it through not discussing it with the right engineers or not knowing of its existence. McKelvey and Page [21] also dis-

☆ Handled by C.-H. Chen.

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http://dx.doi.org/10.1016/j.aei.2013.07.002

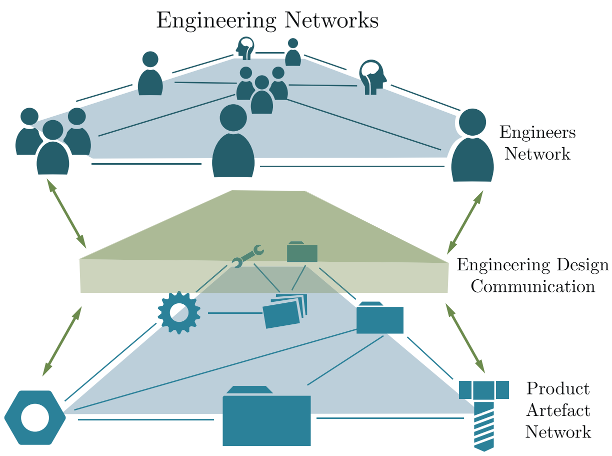

Fig. 1. The Engineers', Communication and Product Artefact Networks.

cusses this effectiveness of communication and highlight that it is a keystone in enabling engineers to draw well-informed conclusions.

Taking a knowledge management perspective, Krishnan and Ulrich [22] consider it to be a crucial knowledge sharing activity between engineer and improvements in knowledge sharing is often associated with gaining a competitive advantage [23]. Interviews by Johnstone et al. [24] confirm that representatives of aerospace companies believe that better knowledge and information management plays a key role in better decision-making. Das et al. [25] discuss how knowledge sharing networks can have a positive impact on increasing productivity within a company by improving the organisational memory. This has been shown to have a further effect on the performance and creativity of New Product Development (NPD) [26].

1.2. Challenges facing the support of EDC

It is well documented that engineers prefer Face-to-Face communication due to its richness and that E-Mail takes over as the dominant communication tool when teams are distributed [27,3,28]. Although this has only recently been the case,[1] which may indicate the slight reluctance to move to new communication tools [29–31]. It is argued that the prominence of E-Mail is due to companies offering support for the communication method and its ubiquity across the entire industry [27]. As well as offering asynchronous communication and reducing the burden of social interaction upon engineers, who often find it difficult [5]. However, E-Mail was never designed to support such highly-contextualised and collaborative communication and has led to trials of other computer-mediated communication tools (such as Instant Messaging [11]). Orlikowski et al. [32] points out that there are issues with E-Mail misuse and that it requires proper governance, and Allen [33] discusses the lack of richness in both E-Mail and telephone, which is required for EDC. Eppler and Mengis [34] reveals that there is often a need for E-Mail etiquette within engineering companies to prevent information overload. It is also the case that many E-Mails within a company are ones that are sent in order to seek the right engineers to communicate with, rather than containing the actual communication the engineer wishes to have [35].

As mentioned previously, Engineering Design is highly collaborative and it is often the case that a communication episode will involve more than two engineers. Popolov et al. [36] discusses how E-Mail struggles to cope with such collaborative communication. In addition, these communications are often held between a small number of engineers and are rarely made visible to others. This prevents the opportunity for other knowledgeable engineers contributing to the communication [37]. It has also been the case that limits have been imposed in almost all implementations of E-Mail in engineering companies, such as restricting the size of an E-Mail and engineers' personal storage space. This can lead to issues in sharing product artefacts and the loss of potentially re-usable communications through deletion [32,38]. Thus, the development of a tool to support EDC would seem a suitable avenue for research in light of the current difficulties. However, there are a number of challenges in addition to what has been discussed.

Tenopir and King [5] and Maiden and Bright [39] discuss the need for such a tool to be able to provide a similar level of context to Face-to-Face communication and the ability for collaboration in order to solve problems, discuss issues and/or make decisions effectively. There is also a challenge in facilitating communications between the right knowledgeable engineers, and Leckie et al. [40] and Lowe et al. [41] show that there is a huge variety in how engineers seek and share information, which is often accompanied by artefacts from the Product Artefact Network (PAN) [42–44]. In addition, it has been shown that engineers seek information from a variety of perspectives (such as where it lies within the company, product and project). There is thus, a need to consider these dimensions when supporting EDC to enable effective search and retrieval [45]. Sim and Duffy [46] discuss how communication has a strong interplay between the engineers and the evolution of the artefacts within the PAN. Thus, it is argued that it would be key for any communication tool to consider how to incorporate these relationships. Finally, Al-Rawas and Easterbrook [47] sum up the current barriers as:

- *The Ineffectiveness of the Current Communication Channels* to support distributed EDC through lack of capturing the engineering context.
- *The Restrictions on Expression within Communication Channels* and particularly enabling engineers to collaborate in a more natural way.
- *The Social and Organisational Barriers*, which include ensuring there is awareness of the communication to enable the right knowledgeable engineers to contribute and ensure the right dimensions are captured alongside the communication to enable easy search and retrieval.

1.3. The potential benefit in improved support for Engineering Design Communication

Improving the support for Engineering Design Communication would not only look to overcome the challenges previously stated but to also provide potential benefits in understanding Product Development. Current research within the field (which includes aspects of Design Rationale and Knowledge Management) has primarily focused upon taking a descriptive approach into understanding how engineers communicate within industry. Often relying on surveys and/or interviews as a means of data capture [5]. There have also been studies that have focused upon particular communication tools within engineering, such as analysing the content of E-Mail or the use of video conferencing [48,2]. In contrast to the wealth of descriptive measures, there are few prescriptive measures to support EDC, be it through the development of a tool or process [5,49,50]. Clarkson and Eckert [49] suggest that the field is reaching a plateau of understanding and intervention research is required to further the field. Hence, the capture of communications through a tool that has been developed to support EDC has the potential to provide a rich dataset that can provide fur-

[1] Telephone had been previously been the main form.