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Using Web 2.0-Based Groupware to facilitate Collaborative Design in Engineering Education Scheme Projects

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Abstract – Employee collaboration is vital for manufacturing organisations wishing to be successful in an ever-changing global market place; it is commonly referred to as the joining of people and interests to meet a common goal via visual or oral interaction, information and knowledge sharing and the coordination of tasks; product development teams operating within the aerospace and defence industry rely extensively on this. To this end, the purpose of this paper is to present the results of a validation study carried out during an Engineering Education Scheme (EES) project initiated by a leading aerospace and defence manufacturing organisation, to confirm the benefits of using bespoke Web 2.0-based groupware to improve employee collaboration between dispersed teams. The results of a cross-sectional survey concluded that employees in the collaborating organisations would welcome greater usage of Web 2.0-based technologies. The study confirmed that groupware offers the potential to deliver a more effective collaborative environment with additional communication channels on offer to end users.

Keywords – Collaboration; Web 2.0; Product Development; Aerospace and Defence Manufacturing; Engineering Education.

I. INTRODUCTION

The last two decades have been characterised by technological advancement highlighted by the birth of the World Wide Web (WWW) and the development of Web 2.0-based technologies, such as social networking sites, social bookmarking and micro-blogging tools; this has resulted in many opportunities for manufacturing organisations, but also significant challenges, especially in terms of employee and project collaboration, with companies today needing to enhance communication channels between geographically-dispersed and co-located employees and external partners.

The Aerospace and Defence Industry (ADI) is an industrial sector which plays a key role in global manufacturing and where the UK enjoys a continuing reputation as a world leader [1]. The industry is renowned for its product innovation and the aerospace industry, in particular, may be considered an example of engineering excellence. The ADI is typified as employing highly skilled and competent workforces, which allow companies to compete effectively worldwide [2]. Engineering practices and standards within the ADI are

typically based upon high quality components, highly technical data and extended development and production lead times [3]. The development of innovative products has now extended its scope to incorporate a wider range of activities and, in addition to greater functional breadth, has to accommodate the geographical dispersement of both internal and external colleagues. To this end, Web 2.0 technologies provide opportunities to enhance collaboration and, thereby, release creativity and foster employee innovation. Since 2006, when McAfee [4] introduced the term Enterprise 2.0 to identify the emerging use of Web 2.0-based technologies in business, dramatic growth in their adoption is evident. By employing Web 2.0 technologies in business, organisations are able to connect people to people and people to information more effectively; facilitate connectivity, sharing and collaboration across boundaries; capture a wide base of views and information that is usually informal or highly dispersed throughout the organisation; help colleagues locate previously unknown experts; and discover hidden organisational knowledge [5]. Published academic research into the use of Web 2.0 technologies in business has focused primarily on the use of individual technologies, such as Blogs [6], Wikis [7], Social Bookmarking [8], Micro-Blogging [9] and Social Networking [10]. However, there is limited research into the adoption and usage of a combination of these tools in the form of groupware, especially within an ADI Product Development (PD) environment.

The purpose of this paper is to report on an investigative validation study conducted following the development and deployment of a bespoke Web 2.0-based groupware, which is introduced in section V, within a leading ADI organisation, BAE Systems, Rochester, and Tonbridge School, a secondary school based in Kent, UK. The study aimed to validate, through a real-world New Product Development (NPD) project, the benefits on offer to ADI companies when adopting Web 2.0 tools within dispersed PD teams.

II. CHALLENGES FACING THE NPD PROCESS

The design and development of both existing and new products traditionally embraces corporate strategy, market research and analysis, the development and testing of prototypes and

production planning [11]. Nowadays, however, NPD has extended its scope to incorporate a wider range of corporate activities and, in addition to greater functional breadth, it now has to accommodate the geographical dispersement of both internal and external colleagues, encourage interaction and multi-disciplinary activity and embrace the concept of managing product lifecycles.

The management of products during their lifecycle progresses through several stages, from product conceptualisation, design and manufacture to service and disposal and the need for employee collaboration during all stages of this process is seen as crucial [12]. The fundamental goals of PD embrace *inter alia* reductions in cost and product enhancements in order to meet and ideally exceed customer requirements. However, a key challenge facing the PD process is how to facilitate employee and project collaboration more effectively within NPD teams, particularly sharing and developing concepts, ideas and explicit knowledge.

To this end, Web 2.0-based technologies provide the PD process with greater opportunities to enhance collaborative practices and, thereby, release creativity and foster employee innovation. They are capable of underpinning effective PD and lifecycle management, which in turn can be vital in maintaining competitive advantage and the future sustainability and growth of companies [13]. Web 2.0 technologies can also allow organisations to interact more freely with customers and suppliers located around the world, enabling them to react more quickly and more effectively to market changes and meet agile and lean manufacturing goals.

III. BARRIERS TO CORPORATE EMPLOYEE COLLABORATION

It is recognised [14] that employee collaboration faces numerous barriers in the workplace, which are often due to social or technological factors. Firstly, employee trust is seen as a potential barrier when an employee is deciding whether it is beneficial to engage in collaboration or not, as often they fear that colleagues may take credit for the work they have previously submitted. There is also potential language or cultural barriers which inhibit employee collaboration in multi-national organisations or between collaborating entities; additionally, inconsistencies often exist in corporate policies in relation to employee collaboration, which can result in colleagues being unaware of the procedures and processes to follow when interacting with different sites or business units within the same organisation.

The activity of Knowledge Management, which is researched extensively in its own right, is a significant factor with regard to employee and project collaboration as employees may not know who possesses, within their extended project teams or organisation, the desired knowledge or skill-sets to help them with given tasks. Additionally, employees often perceive knowledge as power and may not wish to contribute their expertise to facilitate collaboration with colleagues during PD projects. Specifically in the case of extended supply or customer chains, barriers may also be perceived in relation to the sharing of proprietary corporate information as employees may see such information being

susceptible to further inadvertent or deliberate external exposure when others are collaborating on projects outside the scope of the project in question.

From a technology point of view, organisations may experience interoperability issues when installing commercial groupware within current IT infrastructures. Lack of employee training and an explanation of the benefits on offer to employees when using new groupware solutions is also identified as a potential barrier to success [15]. From a manufacturing point of view, organisations must ensure that the groupware employed is capable of handling diverse engineering file formats, including Computer Aided Design (CAD) and Product Lifecycle Management (PLM) or other similar file types.

While promoting and adopting the use of Web 2.0-based technologies in enterprise practices, organisations must always seek to minimise barriers as Enterprise 2.0 offers the potential for enhanced employee collaboration in a less formal and intuitive manner.

IV. THE POTENTIAL OFFERED BY ENTERPRISE 2.0 TECHNOLOGIES TO AEROSPACE AND DEFENCE NPD

Since 2006, when Andrew McAfee [4] of Harvard Business School introduced the term Enterprise 2.0 to clearly identify the emerging use of Web 2.0 technologies in the world of business, we have seen a dramatic growth in the adoption of such tools in a business context. Today, extensive amounts of data and explicit employee knowledge exist in various file formats, including images, videos and engineering files, such as CAD documents and work-instructions for assembly line operators. Web 2.0 technologies are considered more social in nature than traditional IT systems and allow for more dynamic interaction between clients and servers, more engaging webpage displays and, ultimately, more direct and participative user-to-user interactions.

The term “Groupware” refers to multi-user collaborative working tools, which assist users when collaborating on common projects. They may be used either synchronously, where users collaborate in real-time (e.g. Instant Messaging), or asynchronously, when users collaborate at different times (e.g. leaving messages for co-workers based in different time zones – micro-blogging or private messaging), effectively creating a continuous work cycle. They allow collaboration to take place between both co-located teams, working at the same business site, and dispersed PD teams, often based at diverse locations, possibly around the world.

Groupware systems are typically studied in the interdisciplinary field of Computer Supported Cooperative Work, where research has primarily been conducted into understanding how people work together using these collaborative systems and how they interact with them [16, 17]. Within industry, groupware solutions, such as Salesforce Chatter, Yammer and Basecamp are predominately offered as one-off packages or as a Software as a Service (SaaS) solution, which may be deployed across various business functions within an organisation or supply chain; these solutions often share common web 2.0 functionality (see Table I), which

allows employees within an organisation to better communicate, collaborate and share information and knowledge with dispersed and co-located colleagues.

TABLE I. EXAMPLE COMMON WEB 2.0 FUNCTIONALITY EMPLOYED

Web 2.0 Functionality	Definition
Micro-Blogging	Users have the ability to post short, character limited messages, to a web feed for others to see.
Instant Messaging	A form of web-based text communication between colleagues and friends at different locations.
Activity Streams	A web-based feed which provides users with regularly updated content.
Wikis	A web-based tool which allows users to create, edit and update personalised web content.
Discussion Boards	A website or web page where users are able to converse in text conversations.
Event Scheduling	An online facility to share updates on forthcoming events together with the ability to invite colleagues to attend or contribute.
Social Bookmarking	The practice of creating a centralised reference list of web documents which may be accessed and edited by colleagues.

There has been limited academic research conducted into the use of collaborative groupware within a PD or manufacturing setting, especially when they are considered within an ADI organisation; previously, academics have focussed on the use of groupware from a knowledge management standpoint [18, 19]. For the purpose of this study, the authors designed and developed a bespoke groupware solution to meet specifically the needs of the two dispersed collaborating organisations. In order to establish which web 2.0-based functionality was required by both parties, informal face-to-face discussion forums were held, prior to development, to debate and agree on the functionality of the preferred solution.

V. ADI ACADEMIC-INDUSTRY CASE STUDY

BAE Systems plc. is a multinational organisation employing, at the time of writing, approximately 88,200 staff worldwide across its range of businesses. The enterprise is the second largest aerospace, defence and security company in the world and in 2013 reported sales of over £18.2 billion [20]. An independent bench-marking study commissioned by BAE Systems [21] showed that practices in relation to employee collaboration within the ADI organisation were judged to be “average” when compared to similar types of organisations. Studies previously carried out by the author of this paper [22, 23], concluded that BAE Systems employees demonstrate a high degree of familiarity with current Web 2.0 technologies, but that little use is being made of these tools in an industrial setting, with employees still relying heavily on traditional means of communication, such as e-mail and face-to-face meetings, for PD project collaboration. Based on the findings of the authors previous work [22, 23], a collaborative groupware was developed and customised using an open-source Drupal solution (Open Atrium) hosted on a remote Linux server at the University of Greenwich; a system diagram is shown in Figure 1 to illustrate how employees of the two collaborating organisations may operate and interact with the

groupware to improve employee collaboration and communication.

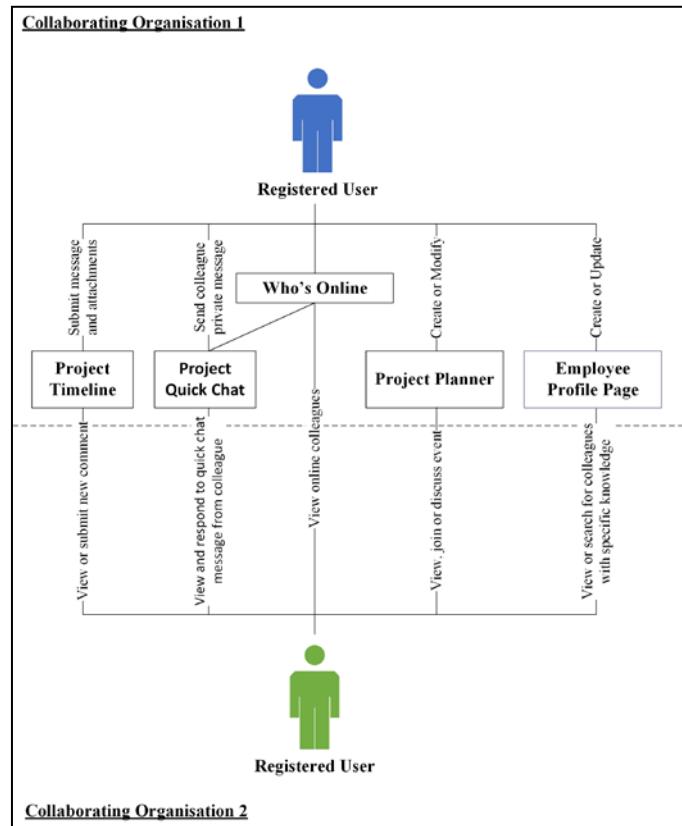


Fig. 1. Groupware System Diagram

The groupware developed employed a range of user-defined web 2.0 functionality, including:

- *Personalised User Profile Pages*, which display contact details for each user, previous work history within the collaborating organisation and relevant knowledge and skills to their job role;
- *Project Timeline*, which allows for group messaging between colleagues, file sharing and content tagging and enables crowdsourcing within project teams to provide users with the functionality to gather feedback on PD ideas and prototypes;
- *Who's Online* notifications, which alert users when colleagues are available for one-to-one instant messaging;
- *Project Quick Chat*, which incorporates micro-blogging functionality allowing users to leave one-to-many messages, which can be read by users when they next log-in to the groupware site;
- *Project Quick Chat*, which incorporates micro-blogging functionality allowing users to leave one-to-many messages, which can be read by users when they next log-in to the groupware site;
- *Project Planner*, which allows for event scheduling, such as daily or weekly project SCRUM meetings;

- *Recent Comments*, which display contributions from team members in a chronological order;
- *Action Alerts*, which notify users when new content or information has been added or updated on the groupware site; and an
- *Advanced Search Facility* which allows users to search for relevant content regarding a project and filter content based on keywords and phrases.

The groupware could be accessed through desktop or laptop computers at each collaborating organisation, as well as through mobile devices; Figure 2 shows the user front-end of the groupware solution, which is displayed when a project team member accesses the groupware tool.

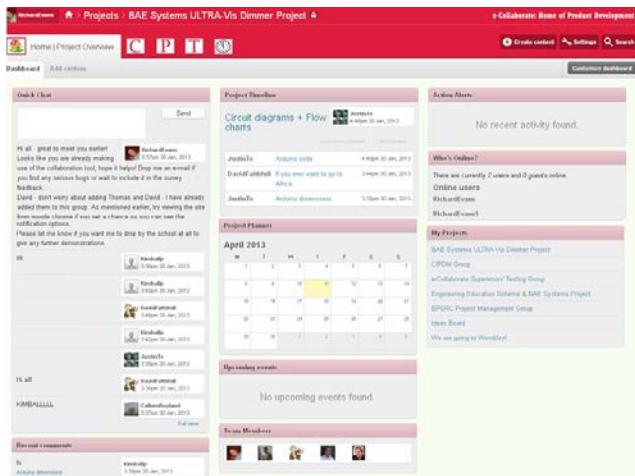


Fig. 2. Groupware User Front-End

An annual Engineering Education Scheme (EES) project has been operated by leading ADI organisation, BAE Systems, for over 10 years and presents engineering students with the opportunity to develop functional prototypes directly relevant to business needs. The project, providing the basis of this case study, called for the creation of an automatic dimming system for use with BAE Systems' ULTRA-Vis system. To facilitate this project, the collaborative groupware developed was employed by all project members.

A validation study of the groupware was undertaken to assess the functionality of the developed solution and to verify the contribution made to enhanced employee collaboration. This was achieved via deployment of the groupware in a real-world PD scenario during the EES project. The geographically-dispersed project group comprised three technologically-aware students from Tonbridge School, the school's Head of Technology, who acted as Project Manager, and two graduate manufacturing engineers from BAE Systems' Electronic Systems, who acted as mentors. The validation study was completed as an ad-hoc activity and deployment of the groupware extended from 30th January to 20th March 2013.

VI. METHODOLOGY: DATA COLLECTION AND ANALYSIS

The methodology employed was an empirical case study, which adopted a web-based cross-sectional survey investigation, hosted on www.smart-survey.co.uk, and an

audio-recorded focus group, which convened post-survey. Surveys were designed to gather feedback from two separate groups, viz. Students ("Team Members") and Project Manager/Mentors ("Managers"). The survey asked Team Members a total of 35 questions and Managers a total of 39 and focused upon the usability of the groupware as both a collaboration and management tool. Feedback was gathered from six users: three Team Members and three Managers. The age profile of the participants ranged from late teens to 60+. In terms of familiarity with current web 2.0-based solutions, all were either moderately or extremely familiar with Facebook and YouTube, but other sites, such as Twitter or Flickr, were less well known to the user group; all users considered themselves moderately or very competent in using these types of user-contributed sites.

VII. RESULTS

The interpretation of the results derived from the survey has been based on a five-point Likert scale as displayed in Table II, while feedback from both Managers and Team Members has been consolidated for analysis purposes, unless any significant divergence of views was noted.

TABLE II. LIKERT SCALE EMPLOYED DURING INVESTIGATION

1	2	3	4	5
Not at All				
Slightly	Somewhat	Very	Extremely	

Findings indicated that employees would welcome greater adoption of Web 2.0-based technologies and a range of potential applications were identified; these included better problem solving, improved sharing of ideas, enhanced project collaboration and more effective employee communication.

With regard to the specific functionality on offer via the developed groupware, diverse views were expressed.

- *Slightly to Very Useful*: Project Timeline, Quick Chat, Recent Comments and Personalised User Profiles were all considered to be useful with scores ranging from 2-4 on the Likert scale;
- *Slightly to Somewhat Useful*: Action Alerts and Project Planner were perceived less positively and scored 2-3;
- *Slightly or Not at All Impersonal*: This positive view was expressed by Managers, although Team Members were somewhat less positive. Interestingly, one Team Member suggested that "it is harder to tell what people are thinking if you can't see their face"; and
- *Somewhat Slower*: Managers and Team Members all expressed this opinion when asked to compare the groupware against traditional methods of communication. It was highlighted that more than one Team Member needed to be online concurrently to ensure satisfactory and speedy employee collaboration.

In relation to a series of open-ended questions regarding the advantages and disadvantages of using the developed groupware, the Managers and Team Members provided differing perspectives. These are now summarised.

A. Managers' View

One Manager identified specific advantages of using the groupware for supervisory purposes – namely, the fact that individuals do not need to be face-to-face; he stated that the groupware “could be very advantageous when project team members are some distance from each other”; indeed, all three Managers recognised the benefits of the groupware for work within dispersed PD teams. When asked whether they would recommend the groupware for project collaboration, the Managers recognised the potential on offer, but suggested that more traditional methods of communication, such as e-mails, were more direct and, therefore, potentially quicker; they felt that the groupware would have to be specified as a preferred collaboration tool in order to encourage widespread adoption. Making a general comment, one Manager in particular liked the concept as “it tries to give a one-stop-shop for all information”, although he did state that “some functionality needs to be added to bring it in line with current expected standards”. Finally, in terms of disadvantages of the groupware, it was reported that there is potential for a lack of personal attention being paid to individuals ... with another layer “between people, things could get done slower”. Furthermore, while Quick Chat was generally seen to work effectively, it was noted that team members ideally need to be logged in concurrently to optimise effective collaboration.

B. Team Members' View

In the case of Team Members, one was particularly positive when using the groupware and identified several advantages: “you can see what people have previously written”; “you can upload pictures, website links and videos for others to view”; “meetings do not need to be planned and you can upload content for people to see at any time”. Indeed, it was noted that the groupware was similar in functionality to more established document sharing platforms. A second Team Member opined that “if you use it from the beginning, it would be easy to communicate with everyone relatively quickly, but you have to use it as your only means of contact, other than face to face”... otherwise, people will revert to e-mail. A third Team Member was most positive stating “I feel it is very productive and useful as it combines many aspects of a project onto one website”. There was little evidence of improved collaborative outcomes being generated through the use of the groupware during this time-limited validation study, but one Team Member did state that it “offered another means of communication and a good way to share files with the group”; the view was also expressed that “we were under time pressure and I believe that using the groupware allowed us to organise ourselves more and get more done”.

The validation study demonstrated clearly that the groupware offers the capability of delivering an effective collaborative environment with additional communication channels on offer to end users. It confirmed that the groupware is usable and accessible to an acceptable standard, although it is evident that a larger sample size and more extensive trialling for a longer period would be beneficial. Indeed, one of the Team Members commented “I think it's a good service; it would have been more useful to my group if we had started the project using the groupware - we were introduced to the service

once we had already got used to using e-mail for project group communication”.

The study confirmed that the specific functionalities offered by the groupware were generally useful and easy to use. Both Managers and Team Members recognised that it could play a key role in document sharing, although the role of email as the primary communication channel would need to be addressed through the further development of the groupware into an in-depth PD collaboration package with comprehensive interoperability meeting current standards. The most positive outcome of the validation study was that clear evidence was provided that the delivered solution could facilitate collaborative processes, with users uploading and sharing their own content for comment and discussion by others; this may be seen as the essence of the challenge when making use of Web 2.0 tools for collaborative purposes.

In conclusion, the study confirmed that Web 2.0-based groupware offers the potential to deliver a more effective collaborative environment with additional communication channels available. With regard to further work, a larger scale real world study is proposed to further validate the conclusions drawn in this paper.

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Any opinions, findings and conclusions expressed in this paper are those of the authors and do not necessarily reflect those of BAE Systems Electronic Systems Sector, BAE Systems Inc. or BAE Systems Plc., the parent organisation.

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