Investigating the Use and Effectiveness of Virtual Collaboration Desks for Collaborative Military Planning

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Abstract

This paper focuses on the use of a Virtual Collaborative Working and Visualisation Environment (VCWVE), i.e. using virtual collaborative desks (VCDs), for the development of shared situational awareness using a common operational picture to support collaborative military planning in joint command and control situations. Joint usability, critical task and situational awareness assessment methods are employed to determine the effectiveness of this VCWVE in supporting commanders’ joint decision making. With reference to the British Army’s seven questions (7Qs) estimate process and intelligence preparation of the battlefield along with a small military judgement panel (MJP) used for the simulation experiment, the research focused on how effectively networked VCDs highlighted commander’s critical information requirements and their evolving requests for information during the planning process.

The research also highlighted how collaborative technologies can not only help to improve joint decision making in a distributed HQ environment but also how an effective plan and its products can be delivered such as: the decision support overlay, the decision support matrix and the synchronisation matrix. As a result of this research a joint usability framework has been developed. This research has military significance in terms of enabling synchronised joint decision making in resilient agile distributed HQ groups and thereby reducing security risk of commander and staff.

1. Introduction

Many of the challenges of the Command and Control process are related to or will be compounded by the requirements for future army forces to participate in distributed collaborations. According to the US Army (2001), distribution of task forces will have a serious impact on the collaborative planning process and collaborative problem solving. This statement illustrates that there is a need for collaborative tools, like VCDs, to provide mechanisms that retain the integrity of the interactive collaborative planning process, synchronization matrix, operation orders, etc. and support effective distributed planning and decision making. Therefore, exploiting information and communication technologies for collaborative working has attracted attention from many industry sectors including the military. The benefits that may be derived through virtual collaborative working are many, whilst being cognisant of any the limitations which may inhibit adoption.

With the reference to the above statement the research objectives of this study were to:

1. Investigate the usability and effectiveness of VCDs for Military Planning in a virtual collaborative working environment;
2. Inform the development of VCD design as an enabling tool for collaborative military planning in a distributed environment;
3. Develop a theoretical framework to inform the product development of a VCD as a tool for military planning in a virtual collaborative working environment.

In accordance with the research objectives, the main purpose of the literature review was to (i) frame the research; (ii) identify the relevant concepts, methods, facts and variables necessary to underpin a qualitative survey framework and research instrument. Hence, this will be used to assess system usability, interface quality and design of the VCD for collaborative military planning effectiveness.

Following the literature review section the remaining sections will: (i) present the research methodology which includes a hypothesised framework and research instrument; (ii) give the basic set of VCD’s features; (iii) describe the experimental procedure; (iv) provide a detailed data analysis; and (v) present the theoretical model developed as a result of the analysis, and research findings drawn from the experimental results. Finally, the concluding statement will highlight what has been achieved from the experiment.
2. Literature Review

2.1. The Driving force behind Virtual Team Collaboration

The emerging knowledge economy, the development of global organizations; global competition and the networked digital technologies that are available, has enabled organisations to create virtual teams to become involved in more complex and dynamic projects (Townsend et al., 1998) in order to improve and create efficient and effective collaboration for organisational benefit and success. Many organisations have realised the benefits of virtual teams, however there are some that still use conventional face to face teams (Martins et al., 2004). However, many organisations are endeavouring to increase their productivity by utilising a mix of collaboration technologies to enable an effective and efficient virtual collaborative working environment.

Virtual teams, unlike co-located teams, replace the need for regular face-to-face interactions with regular, electronically supported virtual interactions. There are numerous definitions on virtual teams that have been composed by researchers in this area, with the majority of the definitions encompassing the use of technology whilst working across different geographical, time, cultural and organisational boundaries (Jennings, 1993; Chase, 1999; Tucker & Panteli, 2003; Duklis, 2006; Igbaria, 1999). For the purpose of this paper virtual teams are defined as: “a distributed organisation that can meet mission requirements without a static spatial frame of reference across time and organisational boundaries using technology enhancements and innovative techniques that allow an organisation to: function, provide transparent and responsive support in order to enhance situational awareness and accomplish its mission” (Duklis, 2006).

It has been acknowledged by Arnison & Miller, (2002) that technology is the fundamental driving force behind the existence of pure virtual teams to engage in collaborative work and is therefore critical to its existence. However, according to Fisher & Fisher (1997) and Haywood (1998), it is not about serving the technology but rather about the technology serving the team as there should be no over optimistic expectation on what the technology can deliver. Lurey & Raisinghani (2001) have candidly suggested that teams could be more effective if provided with the opportunity to meet virtually, if the most advanced technology was made available. However it has been noted by Warkentin et al., (1997) that the technology is only a partial factor for the success of virtual team effectiveness as it has been suggested that these mediums must be supplemented with traditional team practices (i.e. face-to-face meetings).

Keeping synergy and creativity flowing without face-to-face interaction is the greatest challenge to a virtual team (Henry & Hartzler, 1997). Haywood, 1989, has suggested that if virtual teams are not managed properly communication can be less effective than in traditional teams. This is supported by Carletta et al, (1997) who points out that even the best communication via video links etc does not allow as clear communication as face-to-face. Plus there tends to be a psychological distance between the users, which results in more formal interaction. However it is also maintained that a less social presence can sometimes be better as it reduces interpersonal distractions which may interface with logical and analytical abilities Durate and Snyder (1999). When creating effective virtual teams another factor to consider is the personality characteristics of the specific team members and their psychological profiles (allowing individuals to experience each other as being psychologically close or present (Fulk & Boyd, 1991). In order to be successful in a virtual environment, team members need to possess patience, persistence, and perseverance along with a certain degree of tolerance, flexibility, and understanding.

2.2. Physical Interaction and Collaborative Ease of Use

The VCD presents a platform for knowledge sharing, team collaboration and decision making. Performance measurement facilitates individual decision making and gives guidelines for improving team environment and leveraging the support of technology. It is essential to measure the negative outcomes brought about by requirements and limitations of the VCD, such as errors of the system. Likewise it is important to measure the positive outcomes brought about by efficiency and quality. Measures of satisfaction and affect need to be considered too along with identifying the users needs of the VCD.

Virtual collaboration may also impose constraints on communication that is likely to affect a group’s performance. People rely on multiple modes of communication in face-to-face conversation, such as preverbal (tone of voice, inflection, voice volume) and nonverbal (eye movement, facial expression, hand gestures, and other body language) cues. These cues help regulate the flow of conversation, facilitate turn taking, provide feedback, and convey subtle meanings. As a result, face-to-face conversation is a remarkably orderly process. In normal face-to-face conversation, there are fewer interruptions or long pauses and the distribution of participation is consistent, though
skewed toward higher status members (McGrath, 1990). A distinct disadvantage working in a virtual environment is the opportunity to access the usual cues and clues that are acquired via daily interaction on a traditional basis. A small misunderstanding in a virtual team can quickly escalate into an intractable resentment (Way, 2000). Individuals may also see the perceived modes of interaction enabled by the virtual workplace as unreliable leading to unpredictable continuity of their routine interactions and meetings. Virtual members may find it hard to develop positive attitudes towards others and feel uneasy about the activities of the rest of the team.

Using technology as a primary means of communication has been found to significantly delay a project where team members are reliant on the technology as their primary means of communication (Cramton, 2001, Kayworth and Leidner, 2002, Suchan & Hayzak, 2001, Van Ryssen and Hayes Godar, 2000). Team effectiveness can also be reduced because of increased communication problems associated with lags and delay of communication medium. The inability to assess understanding of fellow team members, and team members’ differing frames of reference, language, culture, and motivation to participate can also reduce team effectiveness.

These difficulties are magnified for short-term virtual teams that work under significant time pressure (Cramton, 2001; Galegher and Kraut, 1994; Jarvenpaa et al., 1998; Warkentin and Beranek, 1999). However, virtual collaboration may be the only option for geographically distributed teams to work together. For this reason, virtual teams are frequently employed for atypical and highly specialized projects involving unique information and changing requirements (Robey et al., 2000).

2.3. Cognitive Interaction in a collaborative Virtual Environment

Due to intense information exchange based on a wide range of views of individual team members, collaboration in virtual environments promotes high levels of cognitive complexity. This difficulty can be overcome through knowledge integration and mental model building in order to successfully collaborate and accomplish complex, unclear and interdependent tasks with conflicting dialogue (Vandenbosch & Higgins, 1996). Transactive memory refers to a system where one uses others as memory aids to supplement limited memory and allows the ‘pooling’ of unshared information (Mohammed & Dumville, 2001), to enlarge group memory which is made available and accessible to the group.

The benefit of transactive memory is that specialising knowledge in a group and having a shared awareness of who knows what information, leads to a reduction in cognitive load, therefore increasing the groups cognitive processing capacity in which greater expertise can be achieved as there is less redundancy of effort (Wegner, Erber & Raymond, 1991).

2.4. Virtual Collaboration in the Military Domain

Researchers focusing on organisations working in high-risk areas, such as in the military domain, recognise the importance of having good social, organisational and technological conditions to support communication and information exchange between the involved teams (Johansson, 2005). When there is a heavy workload and time pressure, communication is difficult and thus, team mental models may serve a greater function than when communication is easy (Mathieu, Goodwin, Salas, & Cannon-Bowers, 2000). The military overcome this communication problem through the use of a thinking framework, the Seven Questions (AFM, 2005), which imposes precision, order and discipline. This facilitates an understanding of the common purpose and planning intent. Also, this form of cognitive consensus enables planning teams to interpret and communicate in a similar way (Mohammed & Dumville, 2001).

2.5. Shared Situation Awareness

Situation Awareness (SA) has been defined by (Endsley, 1995) as ‘the perception of all the elements in the environment within a volume of space and time, the comprehension of their meaning and the projection of their status in the near future’. In team decision making the process of achieving situation awareness consists of team members testing out their mental models of the situation by collecting and sharing information and then negotiating to endorse one theory of the situation to use a common frame of reference for the task.

The amount and quality of communication is key to this process. Communication leads to similar expectations. This allows for similar perceptions of environmental information. It is important for team members to have an up to date view of the situation and the state of the task as a foundation is created when there is a development of mutual understanding regarding knowledge, beliefs, goals or attitudes (Kraut, Fussell and Siegel (in press).

Accurate situation assessment in virtual collaboration is the ready access to shared workspaces
comprising the C2 system (Ackerman, 2005) as SA requirements focuses on not only on what the information the planner needs, but also on how the data is presented through various systems and devices and integrated or combined to make operational decisions. Ungvarsky et al’s (2001) study of evaluating commanders using a collaborative software package indicated that soldiers maintained that nothing could ever replace the value of standing around a paper map and discussing the mission.

It does have to be recognised that the move to ‘virtuality’ within the military domain could be very useful in many ways. Traditionally paper maps and acetate overlays have been used predominately in the military to visualise situations. Using a collaborative virtual workspace will reduce the effort required to make changes as well as having the opportunity to reduce or eliminate risk involved of having a centralised Headquarters. Planning products must be disseminated to the appropriate units in a timely manner. The faster plans are distributed the more time there is available for outlining details required to be successful during combat and this can potentially achieved via a virtual collaborative environment.

Thus it is important that the following questions are addressed in the experiment (a) Does the virtual workspace lessen ambiguity or increase it in the planning process; (b) Compared to the co-located planning sessions, did the shared virtual workspace provide the necessary features, functions and interaction mechanisms to support effective co-ordination? (c) Compared to the co-located planning sessions, did the shared virtual workspace provide the necessary features and functions and interaction mechanisms to allow for the necessary dialogues between commanders and his staff to occur?

2.6. Virtual Technologies and HCI

Since all CVEs have to consider interaction via technology, the first consideration is the impact of the user interface. Interaction in HCI is related to how the user can interact/communicate with the system. Interaction techniques have a strong influence on the collaboration in multi user VEs by affecting how individuals act to obtain their goals and disturb the flow of social interaction (Steed et al, 2003). The requirements for social interaction can also make certain demands on the infrastructure of the application.

There are factors of functionality and usability that have to be taken into account in designing a virtual workspace. Research has concentrated mainly on the technical challenges of representing complex spaces, movement and communication (Carlsson & Hagsand, 1993) plus work focusing on the usability of the virtual environment for individuals or collaborating groups (Kaur et al, 1999).

CVEs provide a potentially powerful medium for exploring and communicating in the military domain. Research on the usability of CVEs is still at an early stage; however, there have been some studies of collaborative virtual environments (Tromp et al, 2003 and Heldal, 2003). There are several reasons why there has been so little research on the usability of collaborative virtual environments (CVEs).

According to Schroder et al, (2006) the technology for CVEs is not at a mature stage which has meant that there have been few CVEs available where users could be observed regularly using the CVEs. This in turn has led to severe usability problems of CVEs as these systems have not been regularly used and lack of familiarity (which in the military could affect the planning process greatly).

Many issues like presence, performance, intuitiveness or leadership have been identified as being important in CVEs, and studies have demonstrated that each of these issues might depend on the technology (Draper et al, 1998, Steed et al, 2003).

The factors which lead to the realization of user expectations and hence satisfaction are often difficult to isolate due to their complex inter-relationships. Ditsa and MacGregor (1996) examined a wide range of user satisfaction models and identified the following 4 key factors that can inhibit user satisfaction: (a) The quality of the information from the IS; (b) The user interface features of the IS, (c) The support provided and (d) The user attitudes toward the IS.

Other factors influence interaction on shared virtual workspaces such as the individual’s ability and willingness to collaborate and to use the VCD. Therefore by investigating more about individual factors, the context of the collaborative applications and available technologies, will make it easier to identify critical issues that influence virtual collaborative interaction.

As a result of this literature review, the main variables relevant to this research have been identified and made explicit and may be categorised under the following headings: (a) Physical Interaction; (b) Collaborative Ease of Use; (c) Cognitive Interaction (d) Joint Usability (e) Military Planning Effectiveness (f) Intention to Use.

4. Research Methodology

In accordance with the research objectives and the review of methods in the literature review, the research design adopted in this study was a multi-method approach that is principally a qualitative explanatory
approach. It is combined with a simulation experiment associated with the tasks undertaken in the Estimate Process as outlined by the AFM (2005). The Research Instrument developed contained both structured and unstructured questions to assess system usability, interface quality and design of the VCD for collaborative military planning effectiveness. Ultimately the research instrument and framework developed herein informed the product development trajectory of the VCD for potential exploitation and usage as a military planning tool within a distributed HQ environment. Furthermore, as the nature of the experiment was collaborative, a Military Judgement Panel (MJP) was necessary. Given the same doctrinal background and training of Subject Matter Experts (SMEs), a MJP1 has a central tendency of expertise which is a pragmatic and is an accepted representation of the SME population (DERA, 2000).

3.1 Research Instrument

The QARS (Qualitatively Anchored Rating Scales) technique was developed for this qualitative research. This is a combination of assessing qualitative responses with a 5 point likert guiding scale, to enable respondents in the MJP to gauge their response within a consensus discussion to provide a justified decision outcome. This was appropriate for analysing results collected from a relatively small but representative population, such as a MJP. Furthermore, this was an effective technique for eliciting and making explicit, SMEs tacit knowledge.

The research instrument used in this study drew upon the methods and variables drawn primarily from the literature review. The variables were grouped into principle categories which were defined as: Physical interaction; Cognitive Interaction; Joint Usability; Military Planning Effectiveness and Intention to Use. These categories formed the basis for the development of a high level theoretical framework for assessing technology usability for Planning a Virtual Collaborative Environment.

3.2 Virtual Collaboration Desks: Basic Set of Features

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1 “The power of the MJP lies in bringing the expertise of military and technical specialists to bear on issues that cannot be resolved readily by other more quantitative means. When designed and conducted properly, an MJP can approach the objectivity and rigour of more traditional scientific procedures.” (DERA, 2000)
The conventional approach in conducting the 7Qs estimate process was adopted as the baseline approach and provided a basis for comparison between distributed and co-located military planning.

4.2 De-risking exercise and informing the main experiment

The purpose of the de-risking experiment was to ensure respondents fully understood the nature of the experiment. Secondly, to use Questions 1-3 of the 7Qs process for de-risking and specifying the warning orders, intent schematic and RFIs in preparation for developing the actual plan. (Q1. What is the enemy doing and why? Q2. What have I been told to do and why? Q3. What effects do I want to have on the enemy and what direction must I give to develop a plan?)

Four SMEs participated in the final experiment using a Computer Generated Forces (GCF) application. This was integrated with the VCD. Q4-Q7. Q4 - Where can I accomplish each action/effect? Q5 - What resources do I need to accomplish each action/effect? Q6- When and where does each action take place in relation to each other? Q7. What control measures do I need to impose?) of the 7Qs was the main point of focus and had to be answered in order to generate the products from the Estimate Process namely: Decision Support Matrix (DSM), Decision Support Overlay (DSO), Intent Schematic, Request for Information (RFI) and Synchronisation Matrix.

5. Data Analysis

5.1 Physical interaction

Sharing documents and/or applications is essential for the planning process. This was reported by the MJP as a significant limitation of the VCD. Conflict arose over ownership of shared documents as they were removed from the VCD workspace when they were still in use by another member of the MJP. As a consequence, individual navigation of the documents, including ‘drag and drop’, zoom in and out, and annotation facilities, were very difficult. Therefore this illustrates that further development is required to facilitate users’ intention to use the tool in planning process in the future.

As the SMEs were working on various document simultaneously, all documentation needed to be visible. This was not possible due to the small size of shared high resolution workspace. This was identified as a constraint as it hampered visibility of the shared planning environment. All three communication channels (shared workspace, video, and voice) were used and considered to be functional and equally important in the planning exercise. Despite the low bandwidth limitation, the video screen was a very useful feature for facilitating non-verbal communication and observing body language. Additionally, the pen device was one of the most useful elements of VCD but, as previously mentioned, needs redesigning to provide better functionality for military planning purposes.

5.2 Collaborative ease-of-use

The participants’ perception of ease of use of the VCD was linked to confidence levels and the level of training given. They stated that once confident and better trained the tool should be easy to use. Additionally, knowing the dynamics of working in a distributed way could improve participants’ perception of ease of use of the VCD. It has been identified that the VCD was intuitive to use and the learnability factor was high for using the VCD on a basic level and this was demonstrated quite clearly in the experiment. With fairly minimal training the SMEs managed to successfully conduct the experiment and produce quality estimate products. However, trying to use the VCD’s advanced functions and features was recognised as being more difficult. Therefore, more training and technical support would be required in order to exploit the full capability of the VCD and in order to deal with unexpected events (e.g. documents disappearing) and unfamiliar applications.

Although the tool is perceived to be easy to learn, the complexity of using the VCD in the planning process was relatively high. The main barriers that led to this complexity were: navigation issues, difficulties including ‘drag and drop’ facilities, sharing of documents and using the pen as an input device.

Compared to the conventional co-located planning process, the SMEs were reluctant to agree that the VCD provided the necessary features, functions and interaction mechanisms to support effective coordination, which indicated there are areas for improvement. It was emphasized many times during this data collection exercise that VCD-enabled planning will never be as good as co-located planning.

However, the SMEs did state that it would be “a good second best” solution in a physically distributed environment; especially, in static HQ operations (i.e. Peace support operations, Peace keeping, Peace enforcement, etc.). This analysis confirms that, as a virtual collaborative tool, the VCD enables good team coordination and does enhance team-working.
5.3. Cognitive interaction

Having the ability to successfully disseminate and apply knowledge enables individuals to integrate better that knowledge and apply it to decision making in complex situations (Vandebosch & Higgins, 1996). As a result of the integration of the shared data products created in the Estimate Process and cognitive interaction between commanders using the transactive memory process, Situation Awareness was synergistically raised. This enabled good decisions to be made and the most appropriate Course of Actions to be developed through joint usability of the VCD to facilitate effective military planning.

The Shared data products of the estimate process (DSO, DSM) were assessed in terms of information quality and quantity. Information quality was assessed on the variables of accuracy, trust, relevancy, usefulness and timeliness. The MJP strongly agreed that the first three defined variables scored highly in quality. They also agreed that the VCD facilitated the exchange of sufficient amount of information and knowledge sharing. However, the MJP also did state that this knowledge sharing would have been more enhanced if multiple shared applications had been available. The MJP strongly agreed that trust is a prerequisite of knowledge sharing and is key to successful virtual collaboration.

Due to the limitations of the system ‘Timeliness’ was deemed unsatisfactory. This was supported by a statement made by a SME from the MJP: “We couldn’t see products in real time because of limitations in the number of shared application active and available at the same time”.

As a consequence of the high quality of the shared data products and shared knowledge, shared Situation Awareness was achieved. The SMEs confirmed that a common operational picture could be maintained throughout the planning process. Additionally, the SMEs agreed that the VCD enabled good collaborative decision making, which is further enhanced by a reduction in cognitive load through team work.

The problems reported by the SMEs during the physical interaction with the VCD had a minor influence on the commander’s cognitive process. The pen device was a good example of this. Due to the poor ergonomic design of the pen, the SME acting the role of the commander stated: “I was more concentrated on writing rather than thinking.”

5.4. Joint usability assessment

Efficiency, efficacy and user satisfaction, were used as criteria for assessing joint usability of the VCD and the user’s intention to use the VCD. Compared to a co-located planning process, the efficiency of the distributed VCD in the planning process was not considered as high and did not increase ambiguity of the planning process. The efficacy of the VCD and the potential for errors in the planning process was considered to be very high in a distributed environment. User satisfaction is subject to improvements in the VCD tools, in particular, the pen device, multiple shared applications, better resolution, and bigger shared workspace. Providing these system features/functionalities are in place, the overall SMEs’ satisfaction level in usage would be high. The SMEs are positive that the VCD is suitable for decision making and joint usability in the planning process in a distributed environment. They have clearly indicated that they would be comfortable in using this for planning purposes in a distributed environment in the future, subject to certain feature improvements and design changes that have been previously mentioned.

5.5. Military Planning Effectiveness

Military Planning Effectiveness (MPE) is best measured in the context of utility. This takes into account positive and negative aspects and measures the degree of success as a trade-off. The independent variables of the MPE associated with utility were identified as being: product quality, process quality, accuracy, productivity and workload.

The results of the experiment illustrated that the overall products such as the Intent Schematic, RFIs, DSO and Synchronisation Matrix were good. Productivity was good in the virtual environment and the participants generally followed the planning process. The respondents managed to achieve a sufficient level of debate regarding the planning process and were able to create an effective and accurate plan.

6. Theoretical Framework and Salient Findings

It has been possible to determine linkages and a logical sequence of the five previously mentioned principal categories that are required to form the basis for an effective planning process in a military environment using a VCD. As a result of this a theoretical model for assessing technology usability, functionality and acceptability of an interactive virtual collaborative system in military planning process was formulated (See Figure 1). Additional subcomponents were added as integral parts of the Physical and Cognitive interaction elements. Its purpose is twofold: first, to demonstrate the process of product development through the evaluation of the system
usability and its transferability into customers’ benefits that ultimately inform their intention to use the system. Secondly, to raise the TRL (Technology Readiness Level) as a result of feedback obtained regarding modifications of the VCD.

Findings from the evaluation experiment indicate that the VCD for military planning purposes is still at the lower end of the Technology Readiness Scale and requires further development to facilitate: (i) users’ intention to use the tool for planning purposes in a distributed environment and (ii) system validation in a military environment. It is evident that the main areas for system improvements are: moving and navigation of documents, pen redesign, sharing of multiple applications, size and resolution of the shared workspace, and overlay implementation. Hence, there is a link between users’ Intention to Use the tool and the TRL. This stipulates a series of validating contexts and qualification criteria that must be carried out for technology maturation and successful mission operation.

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Figure 1. Technology Usability and Acceptance Model for Military Planning in a Collaborative Virtual Environment

All three communication channels on the VCD, namely, shared workspace, video and audio, were considered by the SMEs to be functional and equally important. They provided not only common workspace but also facilitated preverbal (tone of voice, inflection, voice volume) and nonverbal (eye movement, facial expression, hand gestures, and other body language) cues, all of which are modes of face-to-face communications (McGrath, 1990).

Hierarchical army structure, strong leadership, military cohesiveness, communication through the established military thinking framework (i.e. the 7Qs estimate process) and group expertise employed in this study eliminated the related problems associated with effective collaboration encountered in the general literature. The VCD-enabled the move to ‘virtuality’ has military significance as the VCDs can enable the maintenance of commander’s leadership in a distributed planning environment as well as synchronous multi-channel information sharing with his staff.

Overall system usability of the military planning process, assessed through the three measures of performance; namely, efficiency, efficacy and effectiveness of the VCD was found to be satisfactory. However, the findings have illustrated that a redesign of some features/functions of the system is required. This is based on the recommendations provided by the MJP. Once these design issues have been addressed it will enable the VCD to move to higher levels in the TRL, so that it is fit for military business purpose.

7. Conclusion

It can be concluded from the findings that there is an overall positive confirmation of the usefulness of VCDs in the military planning process. Despite scenario limitations, experiment constraints and resource restrictions, the SMEs performed well during the experiment and were able to deliver serviceable planning products. They worked synchronously as a cohesive team and managed to maintain good shared situation awareness and produce good quality estimate products. Once design issues have been addressed, this would suggest that SMEs working in a virtual environment would be able to communicate as effectively as face-to-face cohorts (Chidambaram et al, 1990-1991). Contrary to the literature findings, military grouping related activities (i.e. G2 – Intelligence, G4 – Logistics, G6 – Communications etc.) increase the benefits of transactive memory (Wegner et al, 1991), which in turn reduces cognitive complexity in a virtual environment. This has been confirmed by the experiment as the Transactive memory system enables the ‘pooling’ of unshared information. Hence, enhancing shared awareness which in turn increases the team’s cognitive processing capacity (Mohammed & Dumville, 2001 and Wegner, Erber & Raymond, 1991). This allows for a greater level of expertise to be achieved in making decisions in situations that involve high stakes, time pressure and uncertainty. It has also been identified that working in a CVE takes collaborative working in the military environment to another level and enables synchronous information sharing with the ability to put plans together at a faster pace than what is done conventionally.

The experiment results have demonstrated that some of the findings from the general literature on virtual teams may not necessarily be applicable to the military domain. Firstly, military cohesiveness and exposure to the same doctrinal principles reduces or even eliminates the lack of meaning and understanding caused by the absence of physical contact in virtual
teams (Durate and Snyder, 1999). Secondly, barriers that exist in non-military environments, such as: rank, position, service or force affiliation that prevents the development of trust (Cross et al, 2004), are not issues in the military domain. This is due to the highly hierarchical organisational structure, common training and the same doctrinal approaches.

A review of the literature on virtual collaboration and the experiment has identified the factors that enable successful virtual collaboration and have had a positive influence in the military domain. Specifically: clearly defined goals and objectives and communication through established frameworks (Lurey and Raisinghani, 2001; Henry and Hartzler, 1998; Fisher and Fisher, 1997; Haywood, 1989). In this case the 7Qs estimate process, were considered to be one of the most important factors for successful virtual team working Team cohesiveness, defined roles (Durate and Snyder, 1999), strong leadership, and trust are also essential for the successful functioning of virtual teams. Within the military environment, these traits are part and parcel of the SMEs profile.

Another outcome of this study is that the quality of the planning process and products can never be as good as the traditional approach, but using a VCD can help to improve HQ effectiveness in terms of time to deliver the planning process outputs. Nevertheless, the VCD in its current bulky configuration is not feasible to be used in an operational environment. Working in a virtual collaborative environment has been identified as being good, but utilising a virtual desk will not change the thinking process within the military nor does it change the planning process. The MJP view this tool mainly as supporting the output of the planning process and enabling more efficient and effective communication with a plan delivered to an acceptable standard.

Working in a CVE essentially gives the commander the flexibility to do other tasks. It also enables the commander to focus on the command functions and to have enough control and influence over the planning process. Hence, confirming the importance of the linkage between physical & cognitive interaction. This finding also coincides with earlier studies conducted by McGrath and Hollingshead, (1994); Hightower and Sayeed, (1996) that VCD-enabled military planning process in a physically distributed environment would never be as good as conventional co-located planning.

Despite the numerous benefits of virtual collaborative working tools, their widespread use and full acceptance in the military domain has not yet been fully embraced. In this paper we have considered virtual collaboration tools in distributed planning from a British Army perspective. However, further investigation is necessary to identify and to understand how virtual collaboration technologies can be successfully implemented in joint operational planning between multi-national forces or other coalitions.

This research has provided specific insights and recommendations to take the VCD through the Technology Readiness Levels. The VCD allowed users to achieve a high level of productivity during planning in a distributed environment; especially in a less dense battle-space, such as: peace support operations, peace keeping, peace enforcement etc.

In conclusion, we have determined that the VCD has the potential to fill a capability gap in a distributed military planning environment, providing that the recommendations of this research and its assessment are taken forward and acted upon if the VCD is to be exploited in theatre.

Finally, the theoretical framework derived from this investigation can add value to the body of knowledge as it recommends a systematic sequence of processes necessary to evaluate the effectiveness of the VCDs and the products derived from virtual collaboration in military planning and its Intention to Use this technology in the future.

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