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# Achieving success in collaborative research: the role of virtual research environments

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## ACHIEVING SUCCESS IN COLLABORATIVE RESEARCH: THE ROLE OF VIRTUAL RESEARCH ENVIRONMENTS

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**SUMMARY:** *Due to various challenges and opportunities such as globalisation of research agenda and advancements in information and communication technologies, research collaborations (both international and national) have become popular during the last decade more than ever before. Within this context, the concept of Virtual Research Environments is an emerging concept looking at addressing the complex challenges associated with conducting collaborative research. The research reported within this paper investigated how the success factors of collaborative research can be achieved by deploying a Virtual Research Environment.*

**KEYWORDS:** *Research Collaborations, Virtual Research Environments, Success Factors for Collaborative Research, Collaborative Research Management*

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### 1. INTRODUCTION

The advent of modern communication technologies such as the internet has accelerated the rate of global shrinking. This rapidly shrinking world and the impact of the globalised economy have created research issues which have global impacts. Furthermore, many research projects at university, national or international levels involve researchers from geographically distributed research groups. This naturally demands collaboration among researchers who are geographically distributed so that they can focus on tackling shared challenge (Yang and Allan, 2006; Yang and Allan, 2007). Under this circumstance, the notion of research collaborations has been a growing subject of discussion during the last few decades (Subramanyam, 1983; Katz and Martin, 1997; Smith and Katz, 2000; Laudel, 2002).

Managing any collaboration demands extensive resources and proper infrastructure. With the advancements of modern information and communication technologies, the internet in particular, has extended the possibilities of meeting such demands through a virtual research environment (Yang and Allan, 2007; Singh, 2008). A virtual learning environment (VRE) in its simplest form is a set of web applications intended to enable collaborative research activities beyond geographical barriers. It helps researchers to manage the complex range of tasks involved in carrying out collaborative research (Down, 2008).

The current status of development for VREs seems to be largely focused on technological aspects. The majority of current literature on VREs discusses how modern technologies can be used to develop VREs to establish the resource base and the infrastructure to conduct collaborative research (for example see: Fraser, 2005; Yang and

Allan, 2006; Yang and Allan, 2007; Singh, 2008). To ensure proper take up of the VRE concept within research communities, it is essential to assess the potential of VREs to address the issues and challenges faced by modern research collaborations. However, the issue of how VREs can be used to overcome the challenges of research collaborations have not been addressed adequately in current literature. Accordingly, the research presented within this paper aimed at addressing this gap through an assessment of how modern VREs can address the issues and challenges of collaborative research initiatives. In order to achieve this aim, this paper presents the outcomes of an action research study conducted within the EUROpean and ASian Infrastructure Advantage – EURASIA research collaboration to investigate how the challenges faced by the project could be overcome through the use of a custom built VRE (Virtual Environment for Built Environment Research - VEBER). The paper is structured as follows:

Firstly, the paper presents a thorough literature review on collaborative research and the challenges faced by such initiatives. Secondly, it discusses the background of the EURASIA project and the details of VEBER to establish the case study context. Finally, a discussion is presented detailing the outcomes of the case study and highlighting how the challenges of collaborative research have been addressed through the developed VRE.

## **2. RESEARCH COLLABORATIONS**

Despite the wide acceptance of the concept, there have only been a few attempts to investigate what actually constitutes a research collaboration. Based on the dictionary definition of collaboration, Smith and Katz (2000) have defined a research collaboration as, “the working together of researchers to achieve the common goal of producing new scientific knowledge”. However, this definition is far from giving a definitive answer to the above question as the term “working together” can be broadly defined. Katz and Martin (1997) propose that “working together” can be defined as lightly as the whole international research community, or could be categorised under one big research collaboration as all the researchers around the world working together for the advancement of scientific knowledge. On the other hand, “working together” could be very restrictive to where it includes only researchers who contribute to all the main research tasks over the duration of a research project. Accordingly, Katz and Martin (1997) argue that the boundary of a research collaboration is fuzzy and ill-defined. The views of Smith and Katz (2000) and Katz and Martin (1997) on the definitions of research collaboration add more complexity than solutions to the initial problem: what is research collaboration? Laudel (2002) proposes that, “A research collaboration is defined as a system of research activities by several actors related in a functional way and coordinated to attain a research goal corresponding with these actors’ research goals or interests”. This provides a more cohesive answer to the original question of what research collaboration is, since the concepts of “working together” and “producing new scientific knowledge” are not central to Laudel (2002)’s definition of research collaboration, the element of ill-defined boundaries has disappeared from the equation. At the same time, it seems that the latter definition focuses on functional aspects of collaborations rather than strategic aspects, leading towards a practically sensible working definition for research collaboration. In this context, research collaboration can be viewed as a system to functionally relate a group of researchers together to conduct research which brings in mutually beneficial outcomes to all. However, as the above implies, the benefits of research collaboration may differ from one partner (a partner in this context is a party who is functionally related to other parties within a research collaboration) to another. This raises the question, what initiates collaborative research?

### **2.1 What Initiates Research Collaborations?**

In addition to the drive created by globally applicable research issues, collaborative research initiatives seem to have been influenced by numerous other social, economical and political factors. Among these, the demands of research funding organisations can be placed high in the scale. Especially in social research, funding organisations seem to encourage more and more collaborative research initiatives through the allocation of funds. For example, the European Commission has been the main driver of collaborative research in Europe. Within its successive Framework Programmes (FP), the average number of organisations per project doubled from framework 5 (7.2) to framework 6 (15.1) (Katsouyanni, 2008). As Katz and Martin (1997) highlight, this approach of the funding organisations may have been influenced by potential benefits, such as the possibility of reducing research costs through resource pooling, and less international travel. International research collaborations have the potential of utilising local resources within respective countries for research activities such as data collection in various locales, which would have involved international travel if a single organisation was to conduct the same research. On the other hand, this approach may have been influenced by the revised agendas and objectives of the funding organisations to reflect international associations, and a change of global priority issues, such as climate change and disaster management.

Moreover, the ever increasing demand for diversified expertise within a single research project has also made research collaborations popular both among researchers and funding organisations. This is especially true for multidisciplinary research projects, where the project activities demand expertise from more than one field or domain. In these circumstances, research collaboration between multidisciplinary parties have been shown to be more productive than employing experts from different disciplines to the project (Stokes and Hartley, 1989). Katz and Martin (1997), further highlight that the fall-in-real-term cost of communication is a major influential factor for research collaborations. Indeed, the introduction of World Wide Web, email and other related technologies have drastically reduced the costs of long distance communication and information sharing capabilities, enabling functional relationships among researchers to work within a research project.

While the above factors can lead the research collaborations to be initiated, these do not guarantee success. The next section explores the critical success factors of research collaborations.

## 2.2 Success Factors of Research Collaborations

It has been noted that the way in which collaborative research projects are managed is the key to their success (Barnes et al., 2006). This view has been echoed in literature highlighting success factors for collaborative research. As a part of a thorough literature review and series of case studies, Barnes et al (2006) categorise success factors for collaborative research mainly into two groups; universal success factors and project management related success factors. Universal success factors include mutual trust, commitment, good personal relationships, continuity, flexibility, and leadership, while project management success factors include items such as clearly defined objectives, clearly defined responsibilities, a mutually agreed project plan, realistic aims, adequate resources, defined project milestones, a simple collaborative agreement, regular progress monitoring, effective communication etc. These factors were commonly recognised by other researchers as well. For example, almost a decade before Barnes et al (2006), Dodgson (1996) and Davenport et al (1998) have identified a similar list of critical success factors and some of these factors have been discussed in length in literature to establish its validity. For example Dodgson (1996) discusses “trust” in research collaborations in detail. He explains, that “contractual trust” is beneficial to the research collaborations, where all the parties trust that each of the parties will adhere to agreements and promises. Often, funding organisations require the parties to have explicit partnership agreements to ensure this critical success factor exists within the research collaborations they are funding. In addition, “competence trust” and “goodwill trust” drive the research collaborations towards success by assuring the abilities of partners to each other and by creating mutual respect to each other respectively (Dodgson, 1996).

Success factors for collaborative research discussed in the literature seem to highlight a few common themes. For the purpose of this research, the success factors identified in literature are categorised into four focused elements, as shown in Table 1.

*TABLE 1-Critical Success Factors of Collaborative Research*

Focus element	Success factors	Reference
Trust	Mutual respect and trust among partners, Good personal relationships, Simple collaborative agreement, Clear and honest understanding of each other’s abilities	(Dodgson, 1996; Davenport et al., 1998; Mora-Valentin et al., 2004; Barnes et al., 2006; Mann, 2006)
Commitment Ability and Leadership	Top managerial commitment from all parties, Active participation on project team by all the parties, Adequate resources, specialist and complementary knowledge and expertise of partners, One agreed project leader with required authorities	(Davenport et al., 1998; Barnes et al., 2006; Weck, 2006)
Transparency and clarity	Common goals with no hidden agendas Clear understanding of each partner’s responsibilities and tasks, Clearly defined objectives Clearly defined responsibilities, Mutually agreed project plan, Realistic aims, Defined project milestones, Focused project scope	(Davenport et al., 1998; Mora-Valentin et al., 2004; Barnes et al., 2006; Weck, 2006)
Communication and monitoring	Effective communication, communication and regular contacts with partners, Regular progress monitoring, and Ensuring collaborators deliver, Monitoring project’s progress against agreed milestones	(Davenport et al., 1998; Mora-Valentin et al., 2004; Barnes et al., 2006; Weck, 2006)

Achieving all the success factors will pose a significant challenge for any collaborative research environment. The emerging concept of VREs seems to address some of the barriers that may prevent achieving these success factors. The next section briefly details the concept of VREs to establish how it can facilitate success in collaborative research.

### **3. VIRTUAL RESEARCH ENVIRONMENTS**

VREs are a relatively new application area of modern web technologies and has largely arisen through a series of research projects funded by the UK Joint Information Systems Committee (JISC), starting in 2004. According to JISC, VREs aim at helping “researchers in all disciplines manage the increasingly complex range of tasks involved in carrying out research”. In its current form, a VRE can be broadly classified as a group of web applications. Within a collaborative research project, researchers from different geographical locations can use a web browser in their personal computers to interact with other partner researchers through a VRE.

Current literature discusses various technologies used for the development of VREs. Most of the VREs that have been developed to date have taken existing applications of a similar nature, such as Virtual Learning Environments (VLE), to use as its foundation (for example see: Adler et al., 2004; Yang and Allan, 2006; Yang and Allan, 2007; Singh, 2008). Consequently, the development of VREs has been technology driven, rather than demand driven. As discussed in the “ICT productivity paradox” (see: Solow, 1987), this may lead to a state where the VREs are not sufficiently end user (researcher) focused. It was identified by the authors that an investigation was needed to ensure that current VREs address the demands of collaborative research projects. In order to achieve this, the investigation described in the remainder of this paper examines the degree to which a custom built VRE supports the achievement of the success factors of collaborative research within the context of an international collaborative research project.

### **4. RESEARCH METHOD**

The research problem detailed in the section above was investigated by the authors through a reflective study. The case observed was the European Commission funded international research collaboration entitled EURopean and ASian Infrastructure Advantage (EURASIA). This project was qualified as a case to be observed under this based on following criterion:

1. This is an international research collaboration with 5 partners in 4 countries and spans across Europe and Asia, giving it a global presence.
2. The researchers behind this study had control over the EURASIA project as they are the lead partner
3. The very nature of the EURASIA project design is centred around the concept of a Virtual Research Environment and one of the main activities of the project was to develop a VRE and to use it as the sole administrative hub of the project.

The reflective study approach was appropriate for this research as it is an exploratory study demanding in-depth analysis of how the selected case behaves under pre-established conditions (e.g. how the trust between the parties has been enhanced using the VRE in use). Further, this approach caters for the demands of this research such as an uncontrolled environment and researchers’ interaction within the actual research setting (e.g. the researcher needs to educate the partners on how to use the VRE under different occasions to ensure the capability of the VRE is being used adequately for collaboration)

Researchers have observed the behaviour of the EURASIA project and its success during the first two years of life span. Further, the researchers have intervened when necessary to ensure that the VRE is operational with the intended level of use within EURASIA.

During this period, the success of the research collaboration was measured through the outcomes of steering committee meetings conducted bi-annually. The progress of the project progress and barriers to success were discussed within steering committee meetings. An evaluation of the outcomes of these meetings is presented towards the end of this paper.

Before discussing the results and the outcome, the next section details the EURASIA project and the use of a custom made VRE as a part of its management strategy.

## **5. THE EURASIA PROJECT**

The European Commission funded EUROpean and ASian Infrastructure Advantage (EURASIA) is an international collaborative research project. Five multinational project partners are working in collaboration within this project; three European higher education institutes and two Sri Lankan higher education institutes. The three European partners are located within United Kingdom, Estonia and Lithuania. All the partners are leading higher education institutions that produce construction specialists within their respective countries.

EURASIA focused on capacity building of higher education institutions within the context of disaster management, infrastructure management and facilities management related disciplines. Accordingly, the main aim of the EURASIA project is to foster cooperation in higher education institutions in both Europe and Asia, improve reciprocal understanding of cultures, exchange best practice and strengthen mutual awareness of programs specifically related to disaster recovery management and capacity building. The specific objective of the project is to enhance the capacity of the partner institutions for training, teaching and research activities required for the creation and long-term management of public and commercial facilities and elements of infrastructure associated with post-tsunami activities in Sri Lanka. The project set out to achieve this by: developing and improving the Sri Lankan and EU's staff and postgraduate students' professional and research skills associated with the creation and management of facilities and infrastructure; utilising the teaching experience of the EU University partners to develop a curriculum on the creation and long term management of public and commercial facilities and elements of infrastructure; improving and consolidating academic networks by encouraging systematic exchanges so as to establish a sustainable link between EU and Sri Lankan partner Universities; developing joint institutional systems and procedures for the provision and monitoring of training, teaching and research activities associated with the creation and management of facilities and infrastructure; providing career development opportunities to junior staff through postgraduate study and training programmes with partner Universities; and, disseminating knowledge and interpreting information through joint publications and by conducting lectures, seminars, workshops and conferences.

To achieve these aims and objectives, the partners identified a need to establish a collaborative research environment. Further the multinational, geographically dispersed nature of the partner institutions, demanded this research environment to offer capabilities beyond traditional collaborative working environments. In order to achieve this, it was decided that a Virtual Environment for Built Environment Researchers (VEBER) would be developed.

## **6. THE VIRTUAL ENVIRONMENT FOR BUILT ENVIRONMENT RESEARCH**

As with many other VREs (for example see: Adler et al., 2004; Yang and Allan, 2006; Yang and Allan, 2007; Singh, 2008) VEBER was based on an open source distributed toolset, known as Moodle ([www.moodle.org](http://www.moodle.org)). Moodle was originally developed as a Virtual Learning Environment (VLE). Its use as a VLE has been discussed extensively within current literature and often commended (see for example: Jones and Conole, 2006; Sclater et al., 2006; Eales, 2007). VEBER was developed by taking this toolset as the foundation and by adding and altering functionalities required for a virtual research environment. Moodle is technically a dynamic data driven web application written in PHP and supports a number of different Database Management Systems (DBMSs) as the backend. For the purpose of VEBER, MySQL was selected.

### **6.1 The Development Process**

The development process of VEBER was started by identifying the required functionalities of VEBER to be functional as Virtual Research Environment. These functionalities were mainly identified through brainstorming sessions conducted during the EURASIA project planning stage. These requirements have been identified and incorporated to the VEBER development plan in the following manner.

- Collaboration and Communication support: Traditional communication modes are less capable of meeting the demands of multiple partner institutions and therefore a set of communication tools is to be embedded in VEBER such as announcements, discussions, group email facilities, forums and chat
- Information Handling and Exchange support: A file hosting tool provides a robust platform for information and document handling and exchange. VEBER is to be equipped with file hosting and sharing mechanisms preferably with a common document repository and a private workspace to keep and share private and confidential documents securely.

- Project Management support: Administration across partners are to be supported with shared project calendars, tasks management tools and project monitoring tools.
- Data Collection and Dissemination support: To overcome potential geographical barriers, the VEBER is to be equipped with data collection tools such as online survey tools and online workshop tools.
- Research Training support: VEBER is to be further equipped with learning material repositories, library services and a like.

One of the main challenges of the development process at this stage was to map these requirements with existing web technological capabilities. At this point various collaborative frameworks such as Virtual Learning Environments and Content management systems were evaluated to identify a base framework to support the above identified functional requirements. This analysis provided the basis to select Moodle as a suitable candidate to upon which to build VEBER.

The next development step was the technical process of identifying the resource requirements in terms of hardware and Software. The main requirement was to purchase a suitable web server along with proper network infrastructure. A detailed hardware requirement assessment was conducted to identify the suitable hardware profile of the server to be purchased.

In addition, the following items and services have been used during the development process:

1. 1 Gigabit Ethernet port with a fixed Internet Protocol (IP) address to provide the server with a fast connection to the internet
2. A domain registration (<http://veber.buhu.salford.ac.uk>) and appropriate Domain Name Service (DNS) entries to access the server over the internet. A dedicated email address for the project was also created at this point ([eurasia@salford.ac.uk](mailto:eurasia@salford.ac.uk))
3. IP level firewall protection to minimize possible malicious attacks to the server

This was followed by the installation of appropriate software for the server and configuration to ensure optimum performance levels and maximum security. Microsoft Windows Server 2003 was selected as the operating systems for the server and inbuilt Internet Information Service (IIS) has been used as the web server software to host VEBER as a web application.

Moodle installation was the next step. Moodle was available to download free of charge from <http://www.moodle.org> and has been released under the General Public License (GPL) which allows use and modification of the programme to suit the requirements of the user. As PHP and MySQL are prerequisites for the installation of Moodle, those were obtained (under GPL) and installed in the server prior installing the Moodle.

After installing and testing Moodle, it was modified to create the desired environment and functionalities of the proposed VRE. There were two main structural changes to be implemented.

1. With its basic installation Moodle uses a specific vocabulary to project its role as a VLE. For an example, all the core functionalities of the basic Moodle installation is centred around the terms such as “teachers” and “students”. To be able to use the core functionalities of the Moodle in a virtual research environment, this vocabulary needed to be changed to reflect the context of a VRE. Moodle uses “language files” (a set of PHP files carrying definitions to map Moodle core Constants to language strings) to define its “vocabulary”. A separate “language file” was created for the VEBER, creating structural changes such as re-defining the words such as “teachers”, “students” and alike to be “research facilitators” and “research assistants”
2. The second structural change was related to the organisational unit. In the original Moodle installation the main operational unit was a “course” organising all the roles and activities within that. Moodle further has the ability to incorporate “meta courses” which are essentially containers within which more than one course can be hosted (An analogy to in face to face learning environment would be several courses within a school). To cater for the requirements of the VEBER, this organisational unit has to be completely restructured. This was achieved by customising the core Moodle code. The “research project” was identified as the main organisational unit of the VEBER, while defining a superior and an inferior organisational units to support the “research project”. The superior organisational unit is a container named “research project categories” within which several “research projects” can be hosted, and the inferior

organisational unit is named as “work packages” where within a research project several work packages can be defined.

## **7. ACHIEVING SUCCESS FACTORS OF EURASIA THROUGH VEBER: THE STRATEGY AND EVALUATION**

The functionalities of VEBER described above are essentially geared towards achieving the identified success factors of collaborative research projects. This section presents a descriptive analysis on how these functionalities were used to achieve the identified success factors within the EURASIA project. Further, it discusses the outcomes of the steering committee meetings in order to compare the success of the project compared to the expected results, and to capture how well the success factors identified within literature review was achieved within EURASIA by using its VRE; VEBER.

### **7.1 Trust**

Establishing trust between the partners within the EURASIA project was facilitated by various functionalities of VEBER. Firstly the document hosting facility of VEBER was used to make all the contract documents accessible to partners on demand. These included contracts signed by the funding organisation and the principal investigator, which details the agreed deliverables, milestones and distribution of finances. Moreover, as per the agreed methodology, all the project activities were divided into seven work packages. These work packages are represented as “mini projects” within the main “EURASIA” research project inside VEBER. Leaders for each work package were selected having recognised various abilities of the partners and the methodology of the project ensured decentralisation of authorities, responsibilities and the resources to the partners allowing them to lead separate work packages while ensuring the focus is maintained towards achieving the overall objectives of the EURASIA project.

The structure of VEBER is designed to facilitate decentralisation. VEBER features a multi-layered user authentication mechanism to ensure users are assigned an appropriate level of access. Access levels within VEBER are divided into three main groups; Project administrators, research administrators and researchers. Project administrators can monitor and manage the activities of the overall project. Research administrators have the administrative rights for a specific research project or number of projects. Researchers possess the required level of project level access to complete activities as assigned by research administrators.

The level of access to VEBER for EURASIA partners were determined by each partner’s role. For example, the project co-ordinator of the partner responsible for the work package 1 was given “research administrator” level access to the work package 1, while all the other partners were given “researcher” level access to the same, This ensured that each partner is given adequate level of authority to manage the work activities for the respective work packages they are responsible for while ensuring that they can assign various activities of that work package to all the partners and monitor and manage the same. The project administrator level access is only given to the VEBER administrator and to the project co-ordinator of the funding organisation to ensure the integration of the work packages to achieve the overall EURASIA project objectives.

Accordingly, VEBER helped to achieve the following:

1. Mutual respect between partners through the decentralisation of project responsibilities, management capabilities and resources.
2. Clear collaborative arrangements through defined authority levels and clear recognition of each partner’s abilities.

### **7.2 Commitment, Ability and Leadership**

Further to establishing the “trust” among the partners, decentralisation of authorities within VEBER further helped ensure the required leadership and commitment is maintained for the success of the EURASIA project. While the role of the VEBER administrator represents the top level management from the overall project perspective, dedicated management authorities for each work package leader demanded the required commitment from all the parties. Further, allowing the work package leaders to dedicate work to all other involved parties through VEBER, encouraged the parties to be teamed up and activity involved in all the project activities. Allowing access to the information to all the partners about the project resource allocations, it was made sure that the work package leaders are aware of the resource availability and the resources are properly allocated to project activities.

### **7.3 Transparency and Clarity**

VEBER features various tools to ensure the project is in operation with transparency and clarity. One of the first things to establish within the EURASIA project was the project handbook detailing the roles, responsibilities, activities, time scales and resource availabilities. This handbook along with other relevant documents was made available to all the partners through VEBER, ensuring the transparency of actions and expectations. Further, VEBER has an inbuilt task assignment facility, where the research administrator can assign specific research activities to the researchers along with timescales. For an example, within EURASIA if partner A as the leader of the work package 1 needs to assign a particular task to partner B, this was facilitated through the said feature. When the activity is assigned by the work package leader to the respective partner, once the partner is logged in he would be able to see that task as an item to be auctioned with appropriate timescales as specified by the work package leader. Further, all such actions are listed within a central project calendar available within VEBER, making those activities transparent to everyone. Accordingly, the structure of the VEBER, project handbook and tools such as task assigner and project calendars help the EURASIA to progress with clarity and transparency.

### **7.4 Communication and Monitoring**

Communication and monitoring facilities available within VEBER were some of the most frequently used features. VEBER includes two main communication channels to establish effective communication between partners. Firstly, various forums create the common communication platform ensuring transparency. Having identified the need for project level and work package level communication needs for EURASIA, eight communication forums were established. Seven of those were work package based, where essentially the communication can be limited to only those who are involved in delivering the work package. The main forum is open to the whole EURASIA team and often used to initiate project level discussions. As an example, often the steering committee meeting issues are being discussed within the main EURASIA forum. In addition to the accessibility online, all the forum posts are emailed to all respective parties, thereby increasing awareness among partners. All the participants can opt to receive forum postings in email, either as individual items or “digestive” items where all the postings are delivered as a single email daily or weekly. In addition, Real Simple Syndication (RSS) feeds are maintained for all the forum posts allowing the partners to access the same through their RSS access software.

The second mode of communication available within VEBER is a chat facility, allowing team members to communicate instantly with other online members. This has been identified as one of the most effective communication media to minimise the frustration created by the long response times of other methods such as email. If individual communication is intended between two members, even if both the members are not available at the same time online, this facility can be used to initiate a private discussion as VEBER has the capability to email archived conversations of this facility.

In terms of the project monitoring, the project calendar and individual work package calendars provide required reference points. Further the developed document repository of the VEBER provides a hosting place for identified outputs such as reports. Having completed an assigned task by a researcher, the outcome (e.g. a report) is usually sent to the project administrator. After the review, these outcomes can generally be stored at the document repository allowing the principal investigators and other interested parties to monitor the project progress against set milestones. Having identified the needs in a collaborative environment, the document repository of VEBER was designed with a three tier access strategy. There is a private area within the repository where members can host individual items. Within the second tier, this area is facilitated with an “on-demand” share where each member can authorise other individual members or groups to have either read only access or full access to individual items. That way, the sharing mechanism within the VEBER is fully flexible down to individual items and user levels. The third tier features the common area where all the members can post common items.

Another mechanism embedded in VEBER to facilitate project monitoring is its reports repository. All the partners are required to submit quarterly progress reports to VEBER and these reports are accessible for everyone. Further, the principal investigator submits quarterly and annual reports to the funding organisation and these reports were made available in the reports repository as well. In addition, all the steering committee meeting minutes are made available through this to further enhance the transparency and to increase the project monitoring opportunities. All the partners are given a private area to host their internal meeting minutes within VEBER so that the project monitoring is enabled at a partner level.

Having presented how VEBER was setup to achieve the success factors of collaborative research projects identified through the literature review, the next section presents the evaluation of steering committee meeting within this research to capture the level of the success and drawbacks of VEBER.

## **8. EVALUATION**

During the steering committee meeting conducted after the first six months of the project, several comments were made by the committee members about establishing productive relationships between the partners. It has been identified that some of the partners were not fully aware of the financial arrangements of the project and suggestions were brought up to about establishing formal partnership agreements in accordance with the guidelines provided by the funding organisations. Further, some partners requested more information about the progress reporting mechanisms, specifically about the issue of access to progress reports compiled by all the partners. At this meeting, decisions were made to strengthen the common file hosting area of VEBER to enhance trust of the partners by making all the commonly applicable documents (such as budgetary information) available in a central place. Further, after this meeting the quarterly progress reporting mechanism was changed significantly by making common templates available to all the partners where they can submit all the reports to the VEBER common file share directly to be accessible by all. During the second steering committee meeting held after the first year of the project, several requests were made by the partners to conduct further training sessions on VEBER. Further, a few issues were raised about the private file host feature in VEBER, especially about making selective file shares for joint publication preparations etc. These requests were taken into account during the second year of the project. Two training sessions were conducted; one in Europe and the other in Asia. Further, the common and private file share features were further improved using Microsoft SharePoint technologies. During the third and fourth steering committee meetings, the actual usefulness of VEBER was commended without any suggestions for major changes. The main issue raised during the steering committee meetings about achieving commitment, ability and leadership through VEBER was on improving the level of usage. Partners have commented that despite allocating tasks for partners by work package leaders through VEBER, often additional follow up is needed through other means, mainly due to the fact that not all members are monitoring their task calendars regularly. Suggestions were made to improve the task allocation mechanism in VEBER to incorporate automated email generations for associated members as a mean of ensuring each member is aware of respective responsibilities. Despite the issue identified above, the steering committee members have regularly commented on the potential of VEBER and its value in managing commitments and meeting responsibilities. With the suggestions and improvements discussed in the steering committee meetings related to establishing trust among partners, it was visible that the partners were satisfied with the level of transparency and clarity maintained during the first two years of the project. It was visible at the steering committee meetings that all the partners were aware of each other's responsibilities and commitments, and the consistency of information disseminated among partners was at a high level due to features such as common file hosts and forums. Communication and monitoring facilities embedded within VEBER attracted regular attention of the steering members. Most of the time, these features were highly commended by the users. However, frequent requests were brought up during steering committee meetings for formal and informal training sessions on using these features. It was identified that while some partners have used these features regularly, some partners had problems using these due to various level of ICT skills and knowledge among partners. However, the EURASIA project could not facilitate all the training request due to constraints such as finances and time.

## **9. CONCLUSION**

The demands of current collaborative research projects take many facets. Having evaluated the success factors of collaborative research projects and the capabilities of the modern VREs, the following can be established.

Proper user authentication mechanisms and strategies in VREs can be used to share authorities and responsibilities. A sense of ownership can be achieved in VREs to establish trust and leadership in collaborative research projects. Tools such as project calendars and task assignments in VREs can be used effectively to establish and monitor commitment, transparency and clarity of activities desired for the success of collaborative research projects. Communication tools such as forums, chatting facilities, document and reports repositories can facilitate communication and project monitoring needs in a collaborative environments.

Among the barriers to successful uptake of VREs within collaborative research, extensive training needs, low level of usage due to issues such as lack of appropriate skills and knowledge, problems in establishing and maintaining the expectations and requests of features all the partners can be highlighted.

## 9.1 Way forward

After developing and evaluating the VEBER as a VRE for Built Environment research for three years, plans are now in place to use it extensively to manage a long-term research collaboration (Moratuwa and Salford Teamwork for Researching Built Environment Development - MASTERBLEND) between the University of Moratuwa, Sri Lanka, and the University of Salford, United Kingdom. It is expected that the outcomes of the research reported in this paper can be revalidated further through that initiative.

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