Group decision support systems in value management

Shi Chao Fan , Qi Ping Shen & Xiaochun Luo

Department of Building and Real Estate , The Hong Kong Polytechnic University , Hong Kong

Abstract: Value management (VM) practitioners often encounter problems of lack of active participation and insufficient time and information in decision analysis. The use of a group decision support system (GDSS) is proposed to overcome the above problems by improving the efficiency and effectiveness of VM studies. In order to identify the critical success factors (CSFs) for implementing GDSS in VM studies, an experimental study was conducted to simulate the use of GDSS in VM studies, and then a questionnaire survey was conducted to collect the views of the participants. Factor analysis was used to explore the underlying critical success factors, and the results indicated that certain requirements must be met for the successful application of GDSS in VM studies. In particular, a VM team with an appropriate computer skills mix, and GDSS with good utility were believed to be the most significant underlying factors. Besides these, two other factors, system capabilities and experimental settings, should be also considered in order to achieve a successful application of GDSS in VM studies.

Keywords: Value management, case-based reasoning, group decision support system, construction briefing, critical success factors.

Introduction

Value management (VM) is a structured and analytical process that seeks to achieve value for money by providing all the necessary functions at the lowest cost consistent with required levels of quality and performance (Standards Australia, 1994). As an effective tool in meeting the increasing demands for value enhancement (McGeorge and Palmer, 1997; Barton, 2000), VM has been widely used in many countries in the last five decades. The US government, for example, requires the entire executive branches and all federal agencies to establish and maintain cost-effective VM procedures and processes in all programmes and projects. There has been a surge of interest in VM in the construction industry in Hong Kong, especially since the Asian financial crisis in 1997 (Shen and Kwok, 1999). A number of government departments and private enterprises in Hong Kong have applied VM to ensure value for money for their projects during the project feasibility study stage. The Construction Industry Review Committee (2001) recommended that VM should be used more widely in local construction, because it can help clients and project teams focus on the objectives and needs of the project and all stakeholders, both long-term and short-term.

As a result of technology development, uncertain economic conditions, and fierce market competition, an increasing challenge in current VM practice is that clients demand shorter and more focused VM studies, but the size and complexity of projects subjected to VM studies are continually increasing (Shen and Liu, 2003). Research studies suggested that the limited time and resources available for VM studies have weakened the effects of this methodology, and a number of measures have been proposed to alleviate this problem (Shen, 1997; Kelly and Male, 2001). The authors propose to use the group decision support system (GDSS) in VM studies to improve the efficiency and effectiveness of VM studies through alleviating the problems identified in a recent survey conducted by Shen et al. (2004). This survey has revealed that some VM users encountered the problems of lack of active participation, insufficient time and information in decision analysis. Several experimental studies have been conducted to investigate the effectiveness of using GDSS in VM workshops in the past few years (Fan and Shen, 2004; Shen and Fan, 2005; Fan et al., 2006, 2007, 2008).

As a follow-up study, this paper seeks to identify critical success factors (CSFs) for implementing GDSS in VM studies. CSFs are the conditions that are absolutely necessary and need to be met to ensure the success of the system. The identification of the CSFs will enable the limited resources of time, manpower and money to be allocated appropriately (Chua et al., 1999). First, a list of factors was nominated through a comprehensive literature review and eight face-to-face interviews. An experimental study was then designed and conducted, which was followed by a questionnaire survey to collect opinions on each of the nominated factors from the participants. Based on the data collected through the survey, two statistical methods were employed to analyse the data: (1) the important ranking of these factors was established through a scale rating analysis; and (2) the underlying factors were identified through a factor analysis study.

GDSS use in VM workshops

GDSS use combines communication, computer and decision support technologies to facilitate the formulation and solution of unstructured problems by a group of people (DeSanctis and Gallupe, 1987). GDSS comprises a set of techniques, software and technology designed to focus on and enhance the communication, deliberations and decision making of groups (Aiken et al., 1995; Nunamaker et al., 1997). For almost 20 years, researchers have been studying the effectiveness and efficiency of GDSS in supporting synchronous and asynchronous teams working in both field and laboratory settings. Many research studies have demonstrated that use of GDSS is successful in improving the efficiency, reliability and quality of the group decision-making process (Dennis et al., 1990; Greenbery, 1991; Nunamaker et al., 1996; Adkins et al., 2002). Therefore, investigation of critical factors of using GDSS in decision-making processes has attracted the interest of many researchers and practitioners. Niederman et al. (1996) identified a set of key factors for using GDSS in group meetings through a series of in-depth interviews with 37 practising facilitators. The factors they reported mainly focused on technology-related issues, including participant anxiety, system inflexibility and system reliability. A meta-analysis research study conducted by Dennis et al. (1996) suggested that in general use of GDSS improves decision quality, increases the number of ideas generated, requires more time to complete the task, and has no effect on participant satisfaction. However, the effects depend greatly on the size of the group and whether the process used by the group (solely electronic communication or a combination of electronic and verbal) matches the task (idea generation or decision making). In another meta-analysis research study, Dennis and Wixom (2002) reported that five critical factors should be considered to investigate the effects of using GDSS, i.e. task, tool, the type of group, the size of the group, and facilitation. Sun et al. (2008) conducted a survey to investigate the critical factors affecting learners' satisfaction in e learning. The results revealed that learner computer anxiety, instructor attitude towards e-learning, e-learning course flexibility, e-learning course quality, perceived usefulness, perceived ease of use, and diversity in assessments are the critical factors affecting learners' perceived satisfaction.

In order to produce a comprehensive list of CSFs for using GDSS in VM studies, the critical factors for VM should also be considered. Many research studies on the critical factors for VM studies have been conducted. Through an international benchmarking study, Male et al. (1998) identified 10 CSFs for VM studies, i.e. (1) a multidisciplinary team with an appropriate skill mix; (2) the skill of the facilitator; (3) a structured approach through the VM process; (4) a degree of VM knowledge on the part of the participants; (5) the presence of decision makers in the workshop; (6) participant ownership of the VM process output; (7) preparation prior to the VM workshop; (8) the use of functional analysis; (9) participant and senior management support for VM; and (10) a plan for implementation of the workshop outcomes. In order to identify the key success factors for VM, Shen and Liu (2003) sent questionnaires to 200 VM researchers and practitioners. Fifty-one completed questionnaires were collected and analysed. Four factors were identified: (1) value management team requirement; (2) clients' influence; (3) facilitator competence; and (4) relevant departments' impact. After taking into consideration of all these studies, a list of 12 CSFs was proposed. Table 1 lists all the 12 factors and the corresponding references.

Table 1 The proposed critical success factors with corresponding references

Critical factors	References
Facilitator's knowledge about GDSS (CSF1)	Dennis and Wixom (2002); Male *et al.* (1998); Shen and Liu (2003)
System reliability (CSF2)	Niederman *et al.* (1996); Poon and Wagner (2001)
Large quantity of participants (CSF3)	Dennis *et al.* (1996); Dennis and Wixom (2002); Gallupe *et al.* (1992)
Facilitator's attitude about GDSS (CSF4)	Dennis and Wixom (2002); Sun *et al.* (2008)
Face-to-face environment (CSF5)	Dennis *et al.* (1996)
System responsiveness (CSF6)	Poon and Wagner (2001)
Participants' attitude about GDSS (CSF7)	Niederman *et al.* (1996)
Short duration of workshop (CSF8)	Shen and Chung (2001)
Easy use of system (CSF9)	Niederman *et al.* (1996); Poon and Wagner (2001); Sun *et al.* (2008)
Computer anxiety of participants (CSF10)	Niederman *et al.* (1996); Sun *et al.* (2008)
System utility (CSF11)	Niederman *et al.* (1996); Sun *et al.* (2008)
GDSS experience of participants (CSF12)	Poon and Wagner (2001)

The GDSS prototype-IVMS

A variety of GDSS programs have been built by different universities and organizations since 1980s, and many GDSS packages such as GroupSystems and Decision Explorer are currently available in the market. However, they typically offer a small set of tools such as electronic brainstorming and idea evaluation or voting to support discussion and decision. In order to overcome the problems mentioned above to make the VM process more efficient and effective, more specific functions are required, such as idea generation, function analysis and decision matrices. Hence, a GDSS prototype named Interactive Value Management System (IVMS) has been developed by the research team in the Hong Kong Polytechnic University. IVMS was built based on the Windows SharePoint Services (WSS) designed by Microsoft, which serves as a platform for application development. WSS allows teams to create web-based programs for information sharing and document collaboration, which could help increase individual and team productivity. Including such IT resources as portals, team workspaces, e-mail, presence awareness, and web-based conferencing, WSS enables users to locate distributed information quickly and efficiently, as well as connect to and work with others more productively. Based on the functions provided by WSS, IVMS was an innovative attempt at integrating GDSS with the VM methodology to provide information supports in VM workshops. The system structure is shown in Figure 1.

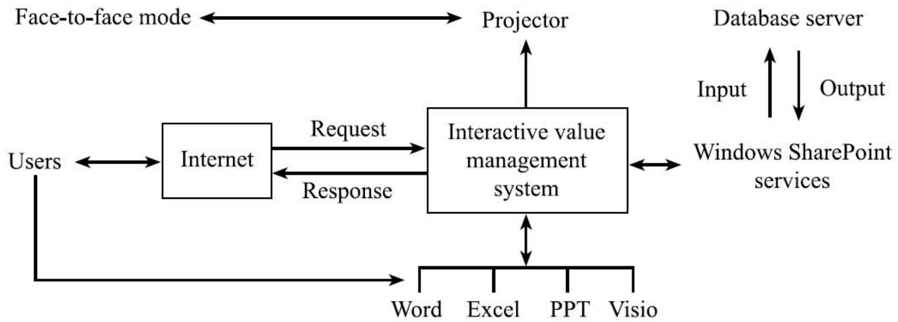

Figure 1 System architecture

IVMS is designed to be integrated with the face-to-face method to exploit the full benefits of both modes of communications (electronic and face-to-face). It aims to facilitate information management, improve communication and assist decision analysis in the VM workshops. Table 2 shows the major supports provided by IVMS in VM workshops.

Table 2 The proposed support provided by IVMS in VM workshops (Fan *et al.*, 2008)

Problems/Concerns	Reasons	Proposed support by IVMS
Short duration	Pressure from the client to cut the cost	Various electronic tools, including document library, electronic brainstorming, weighted evaluation tools, etc. to simplify and standardize the process
Lack of information	• Poorly organized project information in the pre-workshop phase • Difficulty of retrieving project information in meetings	Information support such as document library, electronic discussion board, online questionnaire survey to improve the efficiency of information sharing and enhance information circulation
Lack of participation and interaction	• Shy about speaking in public • Dominated by a few individuals • Pressure to conform	Virtual meeting rooms
Difficulty in conducting analysis and evaluation	• Insufficient time to complete analysis • Insufficient information to support analysis	Electronic tools, including ideas categorizing and FAST diagram, etc. to improve the productivity and accuracy of data processing and eliminate human error
Database of VM studies	Provide references to similar projects in the future	An electronic database that stores VM studies, including the process, the tools used, the objectives and outcomes, etc.
Lack of VM knowledge	Many participants are not familiar with VM	GDSS can act as a teaching tool to introduce the generic process of VM

Research method

Research framework

The specific research method of this research study follows the research model of Chan et al. (2004). They have successfully taken this model to explore critical success factors for partnering in construction projects. This model comprises a literature review, face-to-face interviews, a pilot study, and a questionnaire survey (as shown in Figure 2).

Survey questionnaire

As shown in Figure 2, a literature review was conducted first to develop a research framework for the study. The findings from the literature review also provided a basis for the following face-to-face interviews. A series of factors was also identified during the literature review, and then scrutinized and verified through eight face-to-face interviews. All the interviewees, including VM facilitators, consultants and VM researchers in the UK, were selected because of their eminent experience in value management. All of the eight interviewees, including three TVMs (trainers in value management), two skilled VM facilitators from the construction industry, one professor and two VM researchers from universities, have facilitated or cofacilitated more than 100 VM workshops. The interviews were conducted in the interviewees' head offices, and lasted between one hour and an hour and a half.

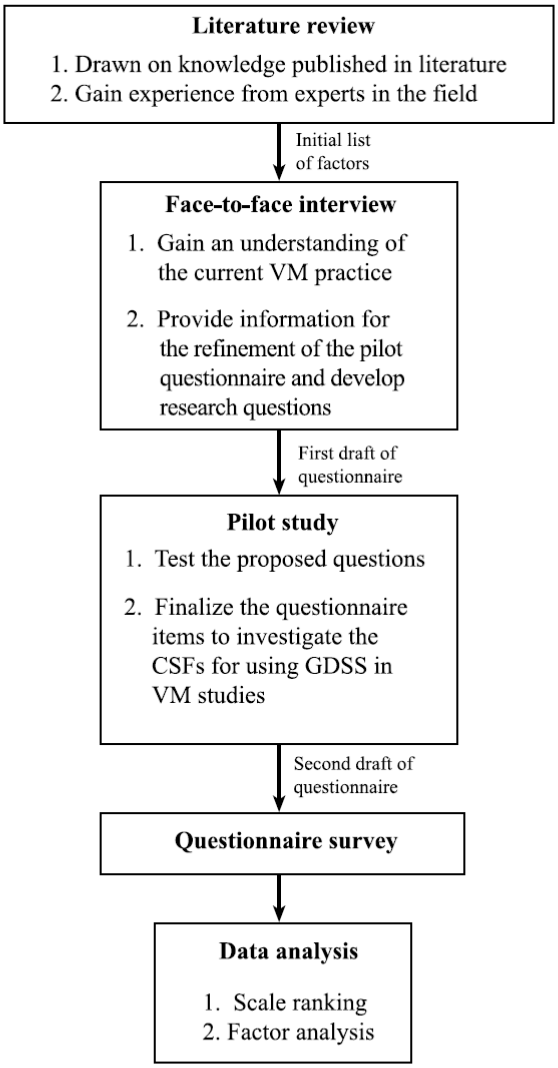

Figure 2 Research framework (adapted from Chan *et al.*, 2004)

During the interview, interviewees' past experiences (e.g. how many VM workshops have been facilitated) in VM were first investigated, which was followed by the questions on the problems encountered by them during VM workshops. Then the general concept of GDSS was introduced, and the supports provided by IVMS were demonstrated. The draft questionnaire was then shown to the interviewees to solicit their ideas on CSFs for using GDSS in VM studies, and their comments were collected to refine the questionnaire. Since no adverse comments were received from the interviewees, the draft questionnaire was taken as the final one during the experimental study. Finally, four perspectives were identified to assess the factors, including participant perspective, facilitator perspective, technology perspective, and workshop perspective (as shown in Figure 3).

In order to validate the results of interviews, an experimental study was designed and conducted. A GDSS room was established to conduct this GDSS supported VM experimental study. A wireless network was set up and a laptop was provided to each participant in order that each user could access the system on his/her laptop during the whole workshop. The projector and a large common viewing screen were also provided in the GDSS room, which were used to display public information. The moveable seats and tables could be arranged in a U-shape or a semi-circle for different situations.

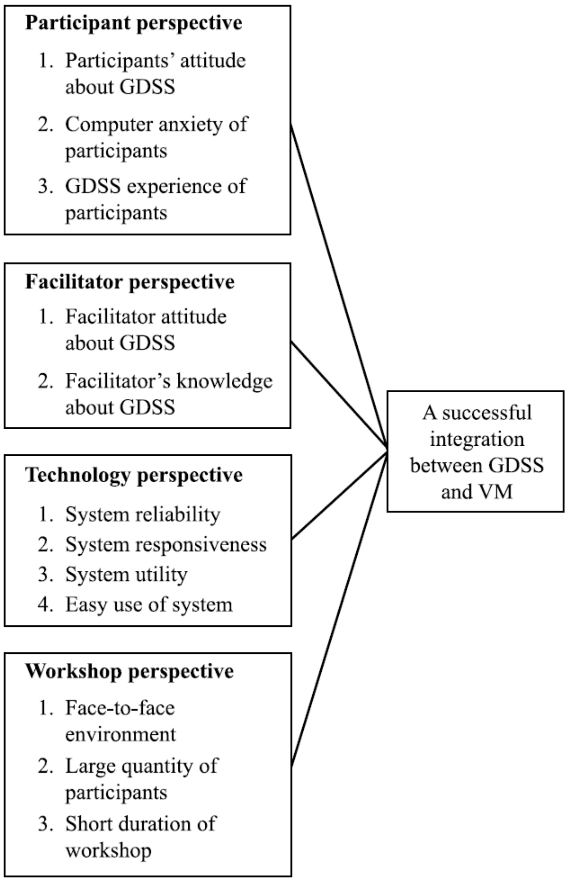

Figure 3 Nominated critical success factors for using GDSS in VM studies

The participants were formed from 42 part-time postgraduate students enrolled in a value management course at the Hong Kong Polytechnic University. An integrated component of the course is a strategic simulation that requires students to organize a VM workshop. All the students have been working in the construction industry for several years. Remus (1986) conducted an experimental study to examine whether there were differences between line managers and MBA students with little business experience in production scheduling decisions. The performance of the two groups was compared in three aspects: the cost of decisions, the amount of erratic decision making and the cost after the erratic component is reduced. No significant differences were found. Briggs et al. (1996) also conducted a study which compared the reactions of graduate business students and working executives to an electronic meeting system. They found no significant differences in technology evaluation between executive business managers and graduate business students. Hence, they suggested that one can get a conservative estimate of the reactions of executives to new technology by testing it with graduate business students. Therefore, based on the above two studies, this research with postgraduate students (who also have real-life experiences) as subjects would help us to achieve a reasonable estimation on the effects of GSSS on real-life VM participants. However, it should be still regarded as a limitation of this study.

A real project in Hong Kong was taken as the task: a cycle track connecting North West New Territories with North East New Territories. There were three main objectives, which were also extracted from the real project:

- to create a structural forum whereby views from all stakeholders on the construction of new cycle track sections can be expressed;

- to discuss and decide what supporting facilities should be provided to enhance the tourism value of the existing and new cycle track network;
- to identify the functions for an education centre to create a structural forum whereby views from all stakeholders on the construction of new cycle track sections can be expressed;

The task description, including project background, scope and objectives, and workshop agenda, was given to the participants three weeks before the VM workshop in order to ensure the participants were fully prepared. Each participant was asked to play a role (e.g. quantity surveyor, civil engineer, representatives from Hong Kong Cycling Association, etc.). The participants were also required to collect background information according to the role s/he would play during the workshop. The duration of the workshop was one and half a days. The workshop was conducted according to the general VM job plan, which consists of six phases, i.e. information phase, analysis phases, creativity phase, evaluation phase, development phase and presentation phase. The whole process of the VM workshop was observed unobtrusively by one researcher. The researcher recorded information relevant to the workshop performance (e.g. typing speed, duration of each session, etc.), and also provided technical support to ensure the system worked smoothly during the workshop.

After the experimental study, the questionnaire survey on CSFs was conducted. Apart from the questions that aimed to collect background information on the participants, the remaining questions required the participants to indicate to what degree each factor related to the success of using GDSS in VM workshops based on a six-point scale, i.e. strongly agree = 6, generally agree = 5, slightly agree = 4, slightly disagree = 3, generally disagree = 2 and strongly disagree = 1. Cox (1980) suggested that the magic number of seven plus or minus two appears to be a reasonable range for the optimal number of response alternatives. Dawes (2007) also argued that simulation studies and empirical studies have generally concurred that reliability and validity are improved by using five- to seven-point scales rather than coarser ones (those with fewer scale points), but more finely graded scales do not improve reliability and validity further. Therefore, a five-point or seven-point scale is usually used. However, the problem is that respondents may be tempted to select the midpoint (Fellows and Liu, 2003). Since the purpose of a rating scale is to allow respondents to express both the direction and strength of their opinion about a topic, a scale without a midpoint would be preferable for it could force the participants not to choose neutral answers (Garland, 1991). For this reason, a six-point scale format was used to improve the reliability and validity and avoid the neutral answers in this research. Thirty respondents returned their completed questionnaire, which represented a response rate of 71%.

Two statistical tools, scale ranking and factor analysis, were used to analyse the data from the survey questionnaire through SPSS (Statistical Package for the Social Sciences).

Research findings

Ranking of critical success factors

The first analysis ranked the factors according to their mean values. If two or more factors happened to have the same rating, the one with the lowest standard deviation would be assigned the highest rank. Table 3 shows the ranking of these factors according to their mean values. From Table 3, it is noticed that ‘facilitator’s knowledge about GDSS’ and ‘system reliability’ are recognized by the respondents as the first two critical success factors.

Table 3 Ranking of critical success factors for using GDSS in value management studies

	Mean	Standard deviation	Rank
Facilitator's knowledge about GDSS (CSF1)	5.23	0.679	1
System reliability (CSF2)	5.06	0.910	2
Large quantity of participants (CSF3)	4.93	0.868	3
Facilitator's attitude about GDSS (CSF4)	4.91	0.993	4
Face-to-face environment (CSF5)	4.90	0.662	5
System responsiveness (CSF6)	4.90	0.759	6
Participants' attitude about GDSS (CSF7)	4.83	0.633	7
Short duration of workshop (CSF8)	4.83	0.913	8
Easy use of system (CSF9)	4.74	0.995	9
Computer anxiety of participants (CSF10)	4.61	0.731	10
System utility (CSF11)	4.46	0.770	11
GDSS experience of participants (CSF12)	4.13	1.383	12

Factor analysis

Factor analysis is a statistical tool that was used to identify a relatively small number of factors that can be applied to represent relationships among sets of many interrelated variables (Norusis, 1993). It can be conducted to reduce a large number of individual variables into a small number of 'underlying' group factors. An underlying factor can be regarded as a linear combination of the original variables. In this paper, factor analysis was used to explore the underlying group factors of the identified CSFs for using GDSS in VM studies. The basic steps in undertaking factor analysis are listed below:

(1) Identify the critical success factors for using GDSS in VM studies.
(2) Compute the correlation matrix for all the critical success factors identified.
(3) Extract and rotate each factor.
(4) Interpret and label principal (grouped) factors as underlying factors.

In this study, 12 CSFs were analysed using principal factor analysis and varimax rotation. Principal components analysis transforms the original set of factors into a smaller set of linear combinations that account for most of the variation of the original set. Various tests are required for the appropriateness of the factor extraction, including the Kaiser-Meyer-Olkin (KMO) measure of sampling accuracy and the Bartlett test of sphericity which tests the hypothesis that the correlation matrix is an identity matrix. Table 4 gives the matrix of the correlation coefficients among the CSFs. The matrix was automatically generated as a part of factor analysis results through SPSS. The Bartlett test of sphericity is 149.143 and the associated significance level is 0.000, which suggests that the population correlation matrix is not an identity matrix. The value of the Kaiser-Meyer-Olkin (KMO) measure of sampling accuracy is 0.679 > 0.5, which can be considered acceptable. All of these tests show that the sample data are appropriate for factor analysis.

Four underlying success factors with eigenvalues greater than 1 were extracted. The principal components matrix after varimax rotation is shown in Table 5. The total percentage of variance explained by each underlying success factor was examined to determine how many factors would be required to represent the whole data. Table 6 presents the percentage of the variance and the cumulative percentage of the variance.

Table 4 Correlation matrix of critical success factors

	CSF1	CSF2	CSF3	CSF4	CFF5	CSF6	CSF7	CSF8	CSF9	CSF10	CSF11	CSF12
CSF1	1.000											
CSF2	0.390	1.000										
CSF3	−0.031	0.031	1.000									
CSF4	0.719	0.438	0.096	1.000								
CFF5	−0.177	−0.287	0.048	−0.099	1.000							
CSF6	0.315	0.438	0.147	0.435	0.048	1.000						
CSF7	0.575	0.485	0.017	0.521	−0.206	0.596	1.000					
CSF8	−0.158	−0.262	0.247	−0.200	−0.200	−0.025	−0.074	1.000				
CSF9	0.440	0.592	−0.029	0.692	−0.261	0.412	0.608	−0.269	1.000			
CSF10	0.470	0.238	−0.130	0.440	0.087	0.188	0.456	−0.360	0.304	1.000		
CSF11	0.210	0.589	0.006	0.440	0.053	0.376	0.344	−0.319	0.562	0.308	1.000	
CSF12	0.627	0.300	0.065	0.531	−0.098	0.145	0.310	−0.419	0.201	0.395	0.018	1.000

Notes: Kaiser-Meyer-Olkin measure of sampling adequacy = 0.679; Bartlett test of sphericity = 149.143; significance = 0.000.

Table 5 Principal components matrix with varimax rotation

	Underlying success factor			
	1	2	3	4
GDSS experience of participants (CSF12)	0.885			
Participants' attitude about GDSS (CSF7)	0.624			
Computer anxiety of participants (CSF10)	0.613			
Facilitator's attitude about GDSS (CSF4)	0.668			
Facilitator's knowledge about GDSS (CSF1)	0.826			
System reliability (CSF2)		0.762		
System responsiveness (CSF6)		0.665		
Easy use of system (CSF9)		0.795		
System utility (CSF11)		0.834		
Large quantity of participants (CSF3)			0.803	
Short duration of workshop (CSF8)			0.632	
Face-to-face environment (CSF5)				0.918

As shown in Table 6, the extracted factors accounted for 72% of the variance in responses. All the factor loadings (see Table 5) are greater than 0.5, and seven of them are greater than 0.7.

Table 6 Percentage of variance and cumulative variance of principal components

Underlying success factor	Initial eigenvalues		
	Total	% of variance	Cumulative %
1	4.59	38	38
2	1.554	13	52
3	1.349	11	62
4	1.173	10	72

Interpretation of underlying success factors

After further investigation of the relationships among the CSFs under each of the underlying success factors, the four extracted underlying success factors can be reasonably interpreted as follows: underlying factor 1 = VM team's computer proficiency; underlying factor 2 = system capabilities; underlying factor 3 = workshop duration and number of participants; underlying factor 4 = environmental setting. These four underlying factors are explained in detail as follows.

Underlying factor 1: VM team’s computer proficiency

All the five CSFs under the underlying factor 1 are related to the computer proficiency of the VM team, including participants and VM facilitators. It can be seen in Table 5 that the participants’ GDSS experience and facilitator’s knowledge about GDSS obtained the highest factor loading. If most of the participants lack experience in using GDSS, additional time has to be spent in training the participants before or during the VM workshop. Therefore it will be better to conduct system training to educate participants in the use of GDSS. Facilitators’ knowledge is also crucial to the success of integrating GDSS in VM studies. By interviewing 37 practising facilitators with a range of GDSS experience, Niederman et al. (1996) suggested that a facilitator can potentially encourage the whole team to positively embrace GDSS technology through her/his GDSS and communication skills; on the other hand, a facilitator’s inexperience with such skills could inadvertently discourage GDSS use as well. Research studies in VM also suggested that facilitator skills were critical to the success of VM workshops (Male et al., 1998; Shen and Liu, 2003). If a facilitator is not competent in the system use, s/he cannot answer the inevitable questions raised by the participants. Moreover, facilitators should understand the features and limitations of GDSS in order to use GDSS appropriately. It is also inevitable that there will be technical problems of one kind or another that need to be solved. It is ideal to have a VM facilitator with necessary GDSS knowledge; however, it may be rare to find both attributes in the same person. Hence, an additional GDSS facilitator, who is skilled in system use, is recommended to assist the VM facilitator during the workshop.

The other three factors are related to the participants’ attitude towards computers. It is true that the computer is used widely nowadays. However, the stakeholders who take part in a VM workshop are usually the senior staff members of their companies. Their computer skills and attitudes towards computer systems may be problematic. This issue may diminish as computer technology continually spreads into modern life. Training is another way to fix the problem. It is recommended to cultivate a positive attitude towards computers among the team through necessary training before a VM workshop. Above all, a VM team with an appropriate computer skills mix is required to achieve a successful GDSS-supported VM workshop.

Underlying factor 2: system capabilities

This underlying factor is about the system capabilities, including the reliability, responsiveness, easy of use and utility. The ability to provide access to reliable data is a major issue in the system development (Poon and Wagner, 2001). The system responsiveness is another important issue. Problems such as the server being too slow or simply unavailable are often encountered especially for web-based systems. Such problems will severely affect the level of users’ satisfaction and the workshop efficiency. Since VM studies normally follow a job plan, which includes six different stages (i.e. information, analysis, creativity, evaluation, development and presentation) with different requirements, it is very important to develop a GDSS based on the special requirements of each stage in VM workshops. A software tool with user-friendly characteristics demands little effort from its users. Users will be willing to adopt such a tool with few barriers and satisfaction will be improved (Amoroso and Cheney, 1991).

Underlying factor 3: workshop duration and number of participants

This factor suggests that better performance will be achieved when using GDSS in a VM workshop with short duration and a large number of participants compared with the one with long duration and a small number of participants. It is in accordance with the research by Gallupe et al. (1992). During their research, they conducted two experimental studies with different group sizes to investigate the effects of group size on the use of electronic brainstorming technology. It was found that the use of electronic brainstorming in larger groups generated more unique ideas and more high-quality ideas, and higher participants' satisfaction compared to verbal brainstorming, whereas there were fewer differences between the electronic brainstorming and verbal brainstorming for the smaller groups. Hence, it was suggested that electronic brainstorming reduces the effects of production blocking and evaluation apprehension on group performance, particularly for large groups. Dennis et al. (1996) also found that large groups benefited significantly more from GDSS use than small groups through a meta-analysis study. Besides, there are usually large numbers of participants in current VM workshops owing to the increasing complexity of projects involved. Therefore, it creates a good opportunity to apply GDSS to the current VM studies to improve the efficiency and effectiveness.

Although the short duration factor is seldom mentioned in the literature, there is a trend that clients demand shorter and focused VM studies because of technology development, uncertain economic conditions and intense market competition, which brings an increasing challenge to current VM practice (Shen and Liu, 2003). Since the main problems encountered in current VM studies are related to the short duration and large numbers of members (Shen and Chung, 2001), it is recommended to conduct a controlled experimental study to investigate the impact of workshop duration on the effects of using GDSS in VM workshops.

Underlying factor 4: environmental setting

The results of the questionnaire show that a face-to-face environment is critical to the use of GDSS in VM workshops. There are normally two situations when using GDSS: the participants of the VM workshops are in the same location with a face-to-face setting; or participants disperse in different locations with video support to ensure the participants can see each other during the workshop. In the meta-analysis study conducted by Dennis et al. (1996), it was suggested that groups with a combination of electronic and verbal communication benefited significantly more from GDSS use (better decisions and more ideas) than groups with solely electronic communication. This is also supported by this research, which suggested that both face-to-face and GDSS have their own advantages and it will be better to integrate the two communication modes together to exploit the full benefits. A series of experimental studies are planned to be conducted by the authors to compare the performance of using GDSS in two different experimental settings: face-to-face and virtual environment, which are expected to further verify the CSFs for using GDSS in VM workshops.

Limitations

The main limitations of this study are the small sample size and the experimental context. Since the subjects of the questionnaire survey should apply GDSS in VM studies before they can have an idea about the CSFs, the authors designed and conducted an experimental study, and invited the potential subjects to join this study. After the experiment, the questionnaire survey was conducted. Unluckily, we only have 42 participants. In the future, more similar studies should be carried out to collect more samples.

Conclusion

Through an experimental study and a questionnaire survey, this paper identified and ranked CSFs for using GDSS in VM studies according to their importance. The outcomes were analysed through factor analysis, and four underlying success factors were extracted: VM team's computer proficiency, system capabilities, workshop duration and number of participants, and environmental setting. The first two factors accounting for 51% of variance in the factor analysis should be given more attention. The VM team's computer proficiency requires a team with an appropriate computer skills mix. System capabilities relates to the system reliability, responsiveness, easy of use and utility. A successful GDSS-supported VM study can only be delivered when the system with user friendly characteristics can provide necessary support constantly and quickly.

Instead of a confirmatory test, the purpose of this research was investigation. It aimed to identify the critical factors that would affect the performance of GDSS-supported VM workshops. All these factors may provide valuable references for both practitioners and VM researchers on how to obtain a successful GDSS-supported VM study. Factors related directly to GDSS among all the factors include VM team's computer proficiency and system capabilities. These issues may be solved by time as the GDSS technologies continue to advance and evolve. However, whenever the practitioners apply GDSS in VM workshops, it is necessary to make sure that the system is reliable and capable and the team has necessary GDSS knowledge, especially the VM facilitator. The other two factors are related to group size, workshop duration and settings. It is indicated that face-to-face VM workshops with large group size and short duration should be recommended for GDSS use. Although the findings are supported by other studies (e.g. Gallupe et al., 1992; Dennis et al., 1996), further verification and validation studies are needed.

A series of controlled experimental studies on the use of GDSS in VM studies should be conducted to verify and validate the applicability and reliability of the CSFs identified during this research. The unit contributions of each factor in the process of implementing VM studies should also be investigated and identified during follow-up experimental studies. The authors have already obtained funds from the Research Grand Council in Hong Kong to conduct a research study on the effects of using group support systems on virtual value management workshops for major construction projects, which will focus on VM workshops with participants dispersed geographically. It will help further verify the above factors, especially the experimental setting factors.

References

Adkins, M., Burgoon, M. and Nunamaker, J.F. (2002) Using group support systems for strategic planning with the United States Air Force. Decision Support Systems, 34(3), 315–37.

Aiken, M., Vanjani, M. and Krosp, J. (1995) Group decision support systems. Review of Business, 16(3), 38–42.

Amoroso, D.L. and Cheney, P.H. (1991) Testing a causal model of end-user application effectiveness. Journal of Management Information Systems, 8(1), 63–89.

Barton, R.T. (2000) Soft value management methodology for use in project initiation—a learning journey. Journal of Construction Research, 1(2), 109–22.

Briggs, R.O., Balthazard, P. and Dennis, A.R. (1996) Graduate business students as surrogates for executives in the evaluation of technology. Journal of End-User Computing, 8(4), 11–17.

Chan, A.P.C., Chan, D.W.M., Chiang, Y.H., Tang, B.S., Chan, E.H.W. and Ho, K.S.K. (2004) Exploring critical success factors for partnering in construction projects. Journal of Construction Engineering and Management, 130(2), 188–98.

Chua, D.K.H., Kog, Y.C. and Loh, P.K. (1999) Critical success factors for different project objectives. Journal of Construction Engineering and Management, 125(3), 142–50.

Construction Industry Review Committee (2001) Construct for Excellence—Report of the Construction Industry Review Committee, Printing Department, Hong Kong Special Administrative Region Government, Hong Kong.

Cox, E.P. (1980) The optimal number of response alternatives for a scale: a review. Journal of Marketing Research, 17(4), 407–42.

Dawes, J. (2007) Do data characteristics change according to the number of scale points used? International Journal of Market Research, 50(1), 61–77.

Dennis, A.R. and Wixom, B.H. (2002) Investigating the moderators of the group support systems use with meta-analysis. Journal of Management Information Systems, 18(3), 235–57.

Dennis, A.R., Heminger, A.R., Nunamaker, J.F. and Vogel, D.R. (1990) Bring automated support to large groups: the Burr–Brown experience. Information and Management, 18(3), 111–21.

Dennis, A.R., Haley, B.J. and Vandenberg, R.J. (1996) A meta-analysis of effectiveness, efficiency, and participant satisfaction in group support systems research, in DeGross, J.I., Jarvenpaa, S. and Srinivasan, A. (eds) Proceedings of the Seventeenth International Conference on Information Systems, Association for Information Systems, Atlanta, GA, pp. 278–89.

DeSanctis, G. and Gallupe, R.B. (1987) A foundation for the study of group decision support systems. Management Science, 33(5), 589–609.

Fan, S.C. and Shen, Q.P. (2004) A web-based group decision support system for Value Management studies in construction, in Proceedings of 2004 International Conference on Construction & Real Estate Management, Hong Kong, 6–7 December, pp. 113–7.

Fan, S.C., Shen, Q.P. and Lin, G.B. (2007) A comparative study of idea generation between traditional value management workshops and GDSS-supported workshops. ASCE Journal of Construction Engineering and Management, 133(10), 816–25.

Fan, S.C., Shen, Q.P. and Kelly, J. (2008) Using group decision support system to support value management workshops. ASCE Journal of Computing in Civil Engineering, 22(2), 100–13.

Fan, S.C., Shen, Q.P., Tang, R.J. and Lin, G.B. (2006) The effect of using group decision support system in Value Management studies: an experimental study. International Journal of Construction Management, 6(2),

49–62.
Fellows, R. and Liu, A. (2003) Research Methods for Construction, 2nd edn, Blackwell Science, London.
Gallupe, R.B., Dennis, A.R., Cooper, W.H., Valacich, J.S., Bastianutti, L.M. and Nunamaker Jr, J.F. (1992) Electronic brainstorming and group size. Academy of Management Journal, 35(2), 350–69.
Garland, R. (1991) The mid-point on a rating scale: is it desirable? Marketing Bulletin, 2, 66–70.
Greenbery, S. (1991) Computer-Supported Cooperative Work and Groupware, Academic Press, London.
Kelly, J. and Male, S. (2001) A quick approach to task fast diagrams, in Proceedings of SAVE International Conference, Dayton, OH, pp. 219–28.
Male, S., Kelly, J., Fernie, S., Gronqvist, M. and Bowles, G. (1998) Value Management Benchmark: A Good Practice Framework for Clients and Practitioners, Thomas Telford, London.
McGeorge, D. and Palmer, A. (1997) Construction Management: New Directions, Blackwell Science, London.
Niederman, F., Beise, C.M. and Beranek, P.M. (1996) Issues and concerns about computer-supported meetings: the facilitator's perspective. MIS Quarterly, 20(1), 1–22.
Norusis, M.J. (1993) SPSS for Windows, Professional Statistical Release 6.0, Statistical Package for Social Science (SPSS) Inc., Chicago.
Nunamaker, J.F., Briggs, R.O., Mittleleman, D.D. and Vogel, D.R. (1996) Lessons from a dozen years of group support systems research: a discussion of lab and field findings. Journal of Management Information Systems, 13(3), 163–207.
Nunamaker, J.F., Vogel, D.R. and Potter, R. (1997) Individual and team trends and implications for business firms, in Advances in the Study of Entrepreneurship, Innovation, and Economic Growth, Vol. 9, JAI Press, pp. 199–247.
Poon, P. and Wagner, C. (2001) Critical success factors revisited: success and failure cases of information systems for senior executives. Decision Support Systems, 30(4), 393–418.
Remus, W. (1986) Graduate students as surrogates for managers in experiments on business decision making. Journal of Business Research, 14(1), 19–25.
Shen, Q.P. (1997) Value management in Hong Kong's construction industry: lessons learned, in Proceedings of SAVE International Conference, SAVE International, Dayton, OH, pp. 260–5.
Shen, Q.P. and Chung, J.K.H. (2001) Using information technology to overcome difficulties in value management studies—Hong Kong's experience. Journal of Construction Research, 2(2), 147–56.
Shen, Q.P. and Fan, S.C. (2005) A group decision support systems for Value Management studies, in Proceedings of 2nd International Conference of Value Engineering and Technology Innovation of Enterprise, 16-18 October, pp. 19–28.
Shen, Q.P. and Kwok, E. (1999) The economic downturn in Hong Kong: crisis or opportunity for sustainable VM applications?, in Proceedings of the 3rd International VM Conference, Hong Kong Institute of Value Management, 6–7 May, pp. 1–7.
Shen, Q.P. and Liu, G.W. (2003) Critical success factors for value management studies in construction. Journal of Construction Engineering and Management, 129(5), 485–91.
Shen, Q.P., Chung, K.H., Li, H. and Shen, L.Y. (2004) A group system for improving value management studies in construction. Automation in Construction, 13(2), 209–24.
Standards Australia (1994) AS/NZS 4183: Value Management, Joint Technical Committee OB/6, Sydney.
Sun, P.C., Tsai, R.J., Finger, G., Chen, Y.Y. and Yeh, D. (2008) What drives a successful e-learning? An empirical investigation of the critical factors influencing learner satisfaction. Computers & Education, 50(4), 1183–202.

Appendix

Questionnaire survey on critical success factors

This questionnaire is part of a research project entitled 'The effect of using group decision support system (GDSS) on the processes and outcomes of value management (VM) studies'. One of the research objectives is to identify critical success factors for the integration of GDSS with activities in the VM process. This questionnaire is designed to collect your opinion about the critical factors of using GDSS in VM workshops. Your replies will be valuable for us to further design a GDSS prototype and investigate the most appropriate way to use GDSS in VM studies. Your support to this survey is much appreciated.

Instructions

Unless otherwise stated, please indicate your answer by circling the appropriate numbers. The meanings of the acronyms are given under the tables. Questions marked with a * are required.

A. Basic information

1.* Your present role in the project team:

☐ Architect
☐ Client
☐ Consultant
☐ Contractor
☐ Engineer
☐ Surveyor

Other: ______

2.* Years of experience in the construction industry ______________________

3.* How many VM workshops have you attended? ______________________

4. Company: _______________

5. To what extent do you agree with the following statement about the VM workshop?

	Strongly Agree	Generally Agree	Slightly Agree	Slightly Disagree	Generally Disagree	Strongly Disagree
I believe that working with computers is very difficult....................................	6	5	4	3	2	1
I believe that working with computers makes a person more productive at his/her job...........	6	5	4	3	2	1
Working with a computer would make me very nervous...	6	5	4	3	2	1
I feel confident using Internet, e.g., using search engines, and locating necessary information on the Internet etc.....................................	6	5	4	3	2	1

B. Critical success factors

	Strongly Agree	Generally Agree	Slightly Agree	Slightly Disagree	Generally Disagree	Strongly Disagree
Participant perspective						
Participants' attitude toward computers will influence the workshop performance.	6	5	4	3	2	1
Participants' computer anxiety will influence the workshop performance.	6	5	4	3	2	1
Facilitator perspective						
Facilitator's attitude towards GDSS will influence the workshop performance.	6	5	4	3	2	1
Facilitator's knowledge about GDSS will influence the workshop performance.	6	5	4	3	2	1
Workshop perspective						
GDSS is applied in a face-to-face environment.	6	5	4	3	2	1
GDSS is applied in the workshops with large number of participants.	6	5	4	3	2	1
GDSS is applied in the workshops with short duration.	6	5	4	3	2	1
System design perspective						
System reliability will influence the workshop performance.	6	5	4	3	2	1
System response will influence the workshop performance.	6	5	4	3	2	1
Perceived ease of use will influence the workshop performance.	6	5	4	3	2	1
Perceived usefulness will influence the workshop performance.	6	5	4	3	2	1
Others (Please specify)	6	5	4	3	2	1
	6	5	4	3	2	1
	6	5	4	3	2	1
	6	5	4	3	2	1

Personal particulars

Name of respondent: ________________________ Position: ________________________