A FRAMEWORK TO ASSESS THE COLLABORATIVE DECISION MAKING PROCESS IN INTERACTIVE WORKSPACES

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ABSTRACT

An interactive collaboration laboratory (ICL) has been established at the University of New Brunswick for the purpose of studying the use of interactive collaborative technologies to improve information management among project team members of the AEC industry and enhance the collaborative decision making process. This paper proposes a preliminary framework that aims to assess the collaborative decision making process by addressing the complexities of group decisions within the AEC industry. The framework consists of identifying the process steps, classifying the process mode and task types, defining assessment parameters, and identifying opportunities for interactive workspace technology support. The framework sets the foundation for an accurate comprehensive analysis of a group decision making process in interactive workspaces. It was designed to compare the decision making process between users of traditional environments, and those of interactive environments, and hence identify the value added to the decision making process for users of interactive workspaces.

KEY WORDS

collaboration, group decision making process, interactive workspaces, information and communication technologies

INTRODUCTION

The AEC industry is an industry faced with continuous impediments that render the process of decision making difficult, and fragmented. In contrast with other industries, stakeholders of the AEC industry usually come from different organizations. That is why their backgrounds, interests, and efforts tend to be different, and divided when working on the same construction project. This understandably creates complexities and conflicts in communication, collaboration, and slows down the group decision making process.

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The pressure to improve productivity, implement new technological solutions, adopt sustainability standards, and work collaboratively has further complicated the decision making process. The AEC industry, traditionally criticized for being a labor intensive industry that relies on manual delivery techniques is now trying to adopt new technological solutions to improve its processes. The push towards implementing sustainability practices has also forced stakeholders to adopt more collaborative means to ensure that multiple project objectives including quality, safety, and most importantly client satisfaction levels are met. This pressure has resulted in a tremendous increase in the number of collaborative decisions that need to be made, and has therefore reinforced the need to enhance the actual group decision making process.

Recent case studies of sustainable design projects have demonstrated a 10% increase in design time because of the increase in collaborative activities when implementing sustainable design standards (Andrews et al. 2006). Although, based on the principles of sustainable construction, the ultimate pay off for the increase in design time should be returned in the life cycle or usage costs, this additional investment in design effort creates a barrier to the adoption of such practices. That is why it was essential to research how ICT solutions could be used to support sustainability standards, improve collaboration between stakeholders, and most importantly prevent time delays and extensions.

The Interactive Collaboration Laboratory (ICL), at the University of New Brunswick (UNB) was established in order to give academics and practitioners, specifically small to medium size players, the opportunity to make full use of the latest "off-the-shelf" technology to enhance their collaborative decision making process. In order to do this, stakeholders need a method to assess how effective their group decision processes are. This paper provides a preliminary framework that would help stakeholders evaluate their group decision making process when using interactive workspaces.

GROUP DECISION MAKING IN INTERACTIVE WORKSPACES

INTERACTIVE WORKSPACES

Interactive workspaces are technologically enhanced group project rooms that are used to solve problems and make decisions collaboratively (Johanson et al. 2004). With their state of the art technology, they give stakeholders of the AEC industry the ability to share information, and communicate together in a more efficient manner. This section summarizes some of the most prominent academic interactive environments available in North America and used for construction purposes, and discusses their role in facilitating the group decision making process within the AEC industry and academia.

Stanford University's Interactive Room (iRoom), located in the Gates Information Science Building and built in 1999, aims to measure and assess users' interaction with large screen displays (Johanson et al. 2002). The room is equipped with three 1.8 m (six feet) diagonal touch screen displays along one wall, and one 1.8 m (six feet) diagonal high resolution front display called the Interactive Mural. The Interactive Mural acts as a large electronic wall, on which users are able to display scattered information, move around data and use it for brainstorming purposes (Johanson et al. 2004).

The Immersive Environments Laboratory (IEL), located at Penn State University is another example of an interactive workspace that aims to enhance collaboration between stakeholders of the industry (Viz Group 2005). The laboratory includes three 1.8 m by 2.4 m (eight feet) positioned at a 120 degree angle so that they can be used in conjunction to provide a virtual reality panorama of VR models (Viz Group 2005). It provides a medium that facilitates users' collaboration and visualization of 3D and 4D CAD drawings, by directly "immersing" them within their virtual reality models (Viz Group 2005).

Finally, the Interactive Collaboration Laboratory located at the University of New Brunswick in Canada, uses off the shelf technology to improve collaboration between stakeholders of the industry. It contains two 1.8 m rear projection wall mounted SMART boards with projector and peripheral, and one 15 m (5 feet) mobile rear projection SMART board with an integrated projector and mobile cabinet (Rankin et al. 2006). The laboratory, similar to the iRoom focuses on using the whole environment, rather than the virtual reality aspect of it, to support AEC scenarios and group decisions.

These interactive workspaces facilitate information management from one side, and improve collaboration and enhance the decision making process from the other. Users of those environments have access to the latest technology that enables them to improve communication among them, capture and document decisions electronically, access information remotely, capture changes instantaneously, and interact in sub-groups in a very informal yet professional manner (Rankin et al. 2006).

GROUP DECISION MAKING THEORY

Group decision making literature within civil engineering and construction has been extensive in its content yet limited in scope. Researchers have focused on investigating decision making techniques that help stakeholders in selecting one out of many available alternative solutions. Some of these techniques include "dominance, conjunctive method, elimination by aspect, simple additive weighting, weighted product, technique for order preference by similarity to ideal solution (TOPSIS), … and goal programming" (Kumaraswamy et al. 2004). The literature has also been very efficient in suggesting and implementing decision support systems that would help stakeholders make more educated decisions. Nevertheless, there has been a lack of focus on the whole decision making process from start to finish; i.e. from defining problems, to evaluating final solutions. Therefore, stakeholders have not been able to assess the collaborative decision making process itself so that enhanced group decisions could be made and planned in the future.

For example, the analytical hierarchy process (AHP) technique enables decision makers to ultimately work through a hierarchy and assign weights to decision alternatives (Al-Tabtabai and Thomas 2004). These alternatives are then ranked according to their weights; with the highest ranking representing the best decision to choose. This technique is well structured because it clearly explains what criteria a decision maker should consider when faced with many alternatives. Nevertheless, it provides no insight on "how" the problem, goal, and objectives should be developed. Moreover, it does not elaborate on how the whole decision making process should be assessed: it lists, explains, and analyzes the steps, but does not provide the decision maker with any feedback regarding the whole process.

Research in this domain appears to have focused on the technical side of the decision making process. Even though decision support systems have been developed to provide decision makers with accurate means to analyze information, they have been very case-specific (McIntyre et al. 1999). Different types of systems have been developed for different types of decisions, hence making it impossible to use one standard decision support system for a variety of AEC problems.

Researchers themselves recognize the limitations of current decision making tools and techniques, and the challenges that lie ahead. According to them, there is a need to balance conflicting objectives, choose proper evaluation criteria, and be objective when it comes to ranking and scoring decision alternatives (Kumaraswamy et al. 2004). Some techniques are difficult for users to grasp, and each technique is not objective enough and therefore not sufficient in making sure the decision maker gets the best fit (Karamouz et al 2003). That is why Karamouz et al. (2003) believe decision makers should not limit themselves to using one technique. They should instead use different techniques in order to generate as many alternatives as possible and use their own judgment afterwards to select the decision that best suits their needs (Karamouz et al. 2003).

This ultimately means that a universal framework for assessing group decisions within the AEC industry does not yet exist. The literature remains restricted to investigating techniques that would evaluate specific decision alternatives rather than one technique that would aim to assess and enhance the collaborative decision process and that would be applicable to all AEC scenarios.

A FRAMEWORK TO ASSESS THE COLLABORATIVE DECISION MAKING PROCESS IN INTERACTIVE WORKSPACES

GENERAL FRAMEWORK

The framework developed in this paper aims to provide a preliminary model for assessing group decisions, and enhancing the decision making process using interactive workspaces.

PROCESS STEPS AND DURATIONS

The general tasks that need to be followed in order to make collaborative decisions are outlined in Figure 1. This model accounts for the unpredictability and complexity of group decisions. The model reflects the fact that some group members may start the process with different tasks, or may proceed from one task to another totally unrelated one. That is why it uses two-way arrows to show all the possible step sequences that could be followed in order to make group decisions. It endeavors to reflect the uncontrollable, yet effective nature of collaborative meetings.

In addition to modeling the tasks, Figure 1 depicts the capture of how much time was spent on every task in the process, and model the time (vertical axis) versus task relationship (horizontal axis). This graph gives the assessor and decision makers a solid idea about the amount of time invested in every task. It thus allows them to judge whether too much or too little time is being spent on any single task. Every box in the graph represents a task in the model, the box height represents the duration of the task, and the alphabetical sequence of letters used inside boxes reflects the temporal sequence of tasks and activities for a particular decision.

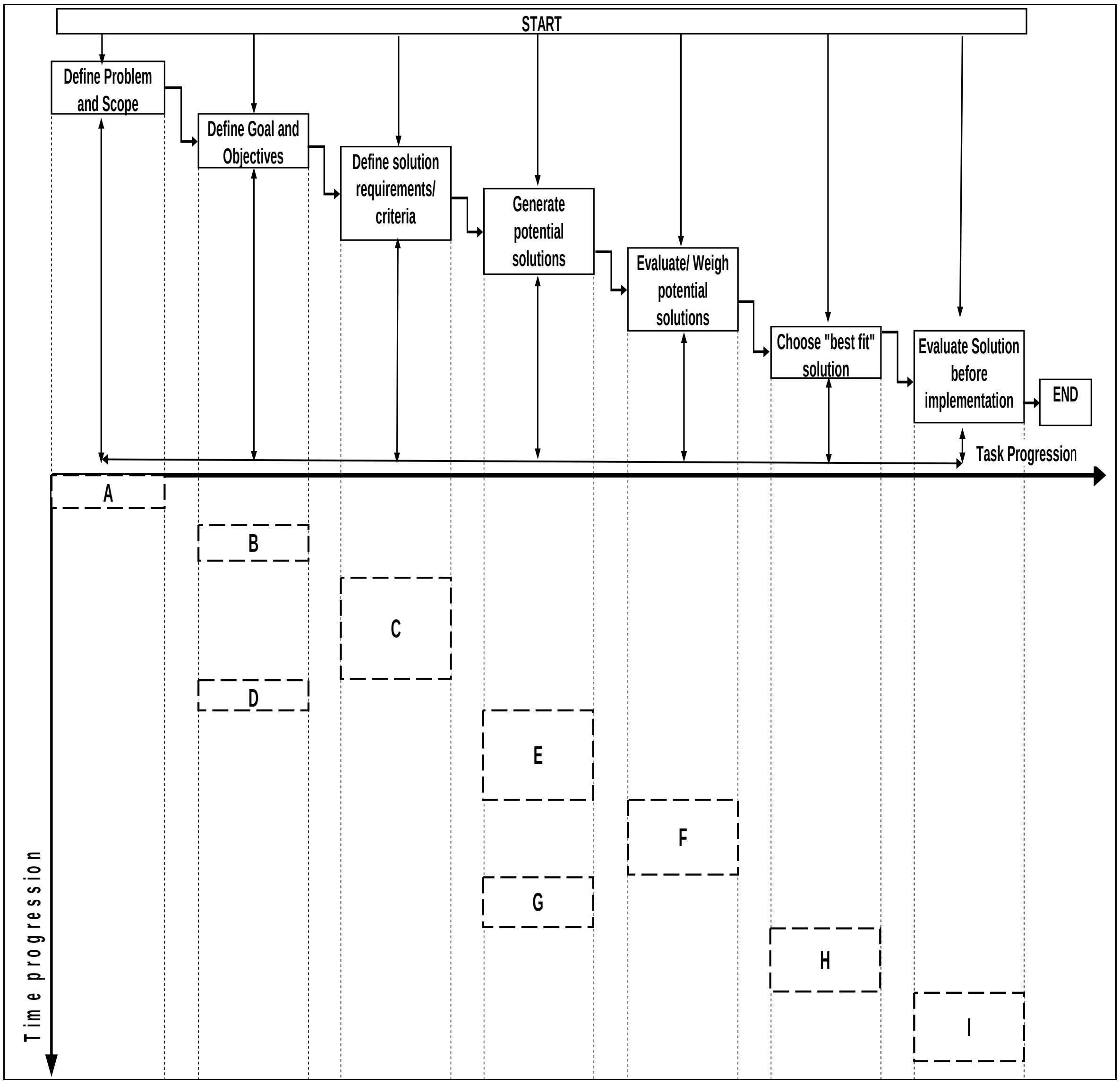

Figure 1: The Group Decision Making Process Steps

STEP REQUIREMENTS AND PARAMETERS

It is important to capture the rigour of each individual step. Therefore, Table 1 lists the set of requirements and parameters that need to be met for each step in the process. The assessor can use this table as a checklist to review the requirements of every step.

Table 1: Task Assessment Parameters for a Group Decision

Step Requirements Assessment	Check if met
Define problem and scope	
Problem identified?	
Scope set?	
Problem captured and documented?	
Scope captured and documented?	
Define goal and objectives	
Goal set?	
Objectives set?	
Goal captured and documented?	
Objectives captured and documented?	
Define solution requirements/ criteria	
All relevant information gathered?	
Solution requirements captured and documented?	
Generate potential solutions	
Potential solutions explored?	
Potential solutions captured and documented?	
Evaluate/ Weigh potential solutions	
Possible advantages explored?	
Possible disadvantages explored?	
Responsibilities allocated?	
Responsibilities assessed?	
Potential solutions captured and documented?	
Choose "best fit" solution	
Every member agrees to solution?	
Final solution captured and documented?	
Evaluate solution before implementation	
Problem solved?	
Scope goal and objectives met?	
Solution evaluation captured and documented?	

MEETING MODES AND TASK TYPES

The next step of the framework entails capturing the amount of time spent on every type of mode and task in the process, expressing every type as a percentage of the total process time, and representing this graphically using a chart such as the chart in Figure 2.

Meeting mode types can be divided into 4 types (Rankin 1997)). “Review” (R) simply explains current task status. “Coordinate” (C) involves discussing information related to a particular decision. “Collaborate” (Co) involves working together toward reaching a solution whereas the “Exception” mode (Ex) addresses exceptional problems encountered in the decision making process that require the input of various members of the group.

Tasks are classified according to Fischer et al. (2000) definitions of decision making task types. Descriptive tasks (D) describe the who, what, where, when and how of a project. Explanative tasks (Ep) explain any interim decisions made collaboratively. Evaluative tasks (Ev) assess the project goals and requirements, and predictive tasks (P) predict the impact of changes on specific decisions. It is important to note that Fischer et al. (2000) applied this classification of task types for the purpose of examining the application of visualization techniques, whereas it is used here for the purpose of examining the decision making process itself.

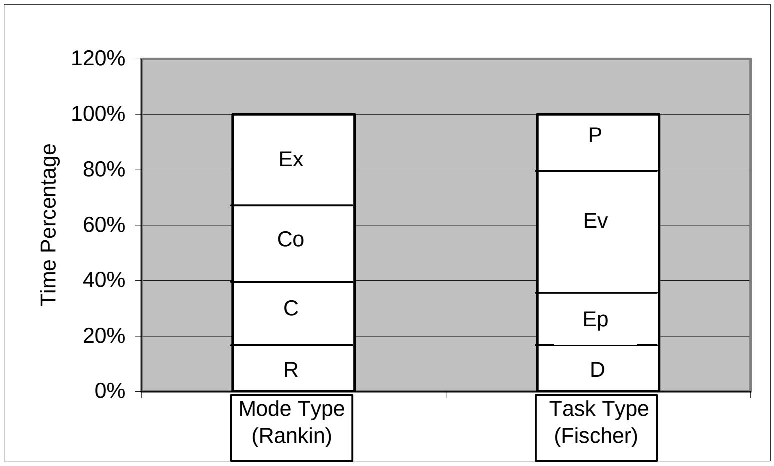

Figure 2: Mode and Task Type Versus Time Graph

Interactive workspaces improve collaboration by supporting stakeholders in evaluating decisions and predict actions with this type of environment than with traditional environments. That is because effective collaborative decisions entail spending more time and effort on evaluative and predictive tasks rather than descriptive and explanative tasks. It necessitates therefore timing meetings, and recording the amount of time spent on every type of task.

INTERACTIVE WORKSPACES SUPPORT TOOLS

The final step of the framework helps identify whether interactive workspaces support tools were used in the decision making process and to what degree of efficiency. For every tool defined in Table 2 the assessor determines whether the tool was necessary, whether it was used, and in what context it was used. The classification of contexts adopted for assessing the use of ICT is that defined by Andrews et al. (2006). A sharing context (S) is a context that supports information communication and sharing. An analysis context (A) explains, interprets, and makes recommendations. An interactive context (I) is one that facilitates a collaborative setting, whereas a documentation context (D) enables capture of information. It is hoped that interactive workspaces will be mostly used to support interactive and documentation contexts rather than analysis and sharing of information.

Table 2: Interactive Workspace Tools Assessment for Group Decision Making Process

Interactive Workspace Tools	Ideally Necessary?	Actually Used?	Usage Context? (S, A, I, or D)
Types of Information			
Textual			
Numerical			
Graphical			
Graphs/Charts			
Spatial/Temporal			
2D Drawings			
3D models			
4D models			
Audiovisual			
Photographs/ Pictures			
Videos			
Hardware			
Computing devices			
PDAs			
Laptops			
Output devices			
Interactive display screens			
Input devices			
Wireless keyboards			
Wireless slates			
Laser pointers			
Digital pens			
Microphones			
Hardware infrastructure			
Remote desktop connection			
Wireless internet connection			
Bluetooth connection			
Software			
Word processors			
Spreadsheets			
Databases			
Presentation			
CAD Software			
Scheduling Software			

FRAMEWORK ASSESSMENT AND EVALUATION

ADVANTAGES

The framework appears promising due to its ability to consider the overall decision making process rather than individual parts of the process. It also provides stakeholders with some means of accurately assessing every step of the process. The model also accommodates the flexibility of collaborative group meetings within construction by taking into account the fact that meetings and decisions could start with any step of the process, and that some steps could be bypassed, or revisited later on. The model also reflects the iterative nature of collaborative decisions, and the stakeholders' tendency to go back and forth to redefine some steps, or make changes when needed.

The framework also endeavors to minimize the amount of information lost or misinterpreted during meetings by making sure that every step of the process is captured and documented properly. It enables stakeholders and decision makers to learn how much time was invested on every type of tasks in order to push them to collaborate rather than coordinate, to predict rather than review, and to evaluate rather than describe. It also allows them to compare different decision making processes by comparing relative amount of times (time percentages) spent on every task or mode type. The framework also identifies the tools used to support collaborative decisions and meetings, and most importantly specifies the context within which each tool was used. An underlying assumption is that the more time and effort stakeholders invest in interacting with the environment's tools, the more efficient their final decision is going to be. It is hoped that the use and implementation of the framework in interactive workspaces will provide evidence in support of this assumption.

LIMITATIONS

The framework has achieved its objectives by identifying whether individual parameters were met, and by calculating time spent on every task relative to the overall time spent on making the decision. Nevertheless, there remains a need to quantify other subjective parameters such as group dynamics, and aspects of human computer interactions which play an important role in decision making in interactive workspaces. Whether subjective factors or considerations could ever be eliminated from this framework or from future decision making tools is debatable though, as there are numerous intangible elements to quantify.

CONCLUSION AND RECOMMENDATIONS

The framework developed in this paper attempts to assess the group decision making process in interactive workspaces. It consists of four main steps: it encompasses a step analysis, a step requirements assessment, a mode and task type analysis and an evaluation of interactive workspace support tools used in the process.

The framework should be of interest to researchers and industry practitioners alike because it addresses key issues impeding the group decision making process. The framework was designed in order to identify the value added to the decision making process when using interactive workspaces. Since the framework has not been extensively used, the potential advantages of these workspaces in improving collaboration, information management, electronic documentation, and capture of relevant information still need to be practically validated.

The framework will require additional refinement during its use. In particular, it needs more accurate assessment methods, and a ranking scheme that would assess the group decision making process as a whole when the decision is finally made. It also needs to reflect important aspects of human-computer interaction, and group dynamics that are more difficult to predict and measure. The framework also raises questions as to the number and skills of assessors needed in order to be able to implement it successfully, and whether video capture devices would be needed to record meetings and assist in implementing the framework.

Interactive workspaces hold a great potential for improving the way AEC practitioners interact, manage information, and visualize it as well. Nevertheless, a framework that helps them reach satisfying conclusions is required if they are to reap the full advantages of the technology available in these environments.

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