An Empirical Study of Group Awareness Information in Web-Based Group Decision Support System in a Field Test Setting

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***Abstract*— Group awareness information is important information for group work. It represents things such as group members' roles and responsibilities, their positions on an issue, their status, and the state of various group processes that group members know about when they work together. The group awareness information presented in this article is designed to capture group member activities and their behaviors in web-based collaborative work. In this article, group awareness information is represented with a visual display. It consists of activity, and availability information. The application of this proposed scheme is designed and implemented in a web-based group decision support system. This article reports on the results of a study that examined group performance on a given task in a Web-Based Group Decision Support System (GDSS) with and without group awareness information in a field test setting. In particular, the study examined how group awareness information impacts the quality of the work effort and a given task, group decision making by members in the same group and different groups, the communications among group members in the completion of an online collaborative authoring task, the cohesiveness among group members in a web-based group decision support system, and the commitment/disposition of engagement of each member of the group.**

Keywords— ***web-based group decision support system, nominal group technique, group awareness information, activity information, availability information, commitment/disposition information.***

I. INTRODUCTION

In a traditional or face-to-face group meeting and/or group decision support system, group members working in close physical proximity have access to a large amount of information about one another. This includes such things as the presence or absence of members of the work group, what they are working on, who they are working with, how actively they are working, how they feel physically and emotionally, etc. This information is obtained directly through communication and indirectly through observation of shared artifacts [1]. Computers are being used more frequently to assist in cooperative tasks [2]. When people collaborate via computer mediation, this information and the opportunity to access it are diminished. Increasing the amount of information about group availability in a computer mediated collaborative support system should increase the group's ability to complete a task. When people work together, they share a task on which they cooperate, one or more artifacts, and a social context. Supporting awareness of the activity of other members in a collaboration team and of changes in the shared work materials is very important in collaborative work systems [3]. Tatar found that people required up-to-date information about others, e.g. who just made a modification, to collaborate effectively in "What You See Is What I See" (WYSIWIS) systems [4]. Moran and Anderson suggest that awareness information is important because it provides information about availability in an indirect way [5]. Generally, people pay attention to the activities of others. The presence and behavior of other people helps to define the meaning of situations for an individual and can have an influential effect on his or her behavior, attitudes, and feelings in interaction in group-work situations [6]. This research outlines issues and opportunities related to the use of tools to improve collaboration. Specifically, it discusses increasing awareness information and information about the status of individuals contributing to collaboration.

A variety of computer-mediated systems have been developed to support group meetings. Group Decision Support Systems (GDSS) have been defined as "an integrated computer-based system to facilitate the solution of unstructured or semi-structured tasks by a group that has joint responsibility for performing the specific task" [7]. Power et al defines a web-based decision support system as a DSS built with web technologies so that the DSS users can access it with web browsers deployed on corporate intranets to support internal business processes or they can be integrated into public corporate web sites to enhance services for trading partners [7]. The goal of a web-based GDSS is to achieve a final group decision with a high level of quality and effective consensus of needs. Web-based GDSS has been well established and continually developed since the year 2000. Researchers have proposed various methods for Web-based GDSS in order to achieve the highest quality of group decisions or tasks. In this article, we propose methods of designing and establishing group awareness information as visual information in a web-based group decision support system and presenting the awareness information to group members when they work

together on given group tasks. The article is organized as follows: Section II presents some more detail about various aspects of awareness information. Section III addresses related work. Section IV describes the design and implementation of group awareness information in a Web-based GDSS in more detail. Section V describes the methodology of the experiment that was performed. Section VI describes the experimental study and the results. Section VII presents a conclusion and discusses some perspectives and ideas for future work.

II. BACKGROUND

There are a number of theories concerning awareness information and cooperative work, but this article only discusses a subset of them. The specific theories discussed have been chosen because they appear to be most applicable to the analysis and design of group awareness information in a web-based group decision support system.

A. Awareness Information

The word awareness, when used in the context of computers, can be defined in many different ways depending on how it is applied and who applies it. Awareness is "an understanding of the activities of others, which provides a context to your own activity" [9]. Greenberg and Johnson present three steps that must be taken to support awareness in collaborative work [10]. First, determine what people need to know about others in the work setting. This information could be used to model the framework of what people need for maintaining awareness in the groupware setting. Second, consider how that knowledge can be gathered and interpreted as part of the information available in the groupware setting. Third, determine how to display that information so that people can obtain and use the knowledge naturally and effortlessly. Maintaining awareness information in a work setting uses two mechanisms. The first is communication, which can be direct or indirect. People in a work setting may inform others by communicating about where they are going to work and what they are going to do. Second, people can gather awareness information by watching others work or by noticing the effects of their actions, which is observation [11]. Therefore, groupware needs an interface through which to present awareness information. The system displaying awareness information must provide some balance between providing awareness and distracting people from their tasks or violating an individual's privacy by providing too much information. These decisions are complicated in that "awareness" as a natural phenomenon is difficult to observe because it is a cognitive activity. Good metrics of "awareness" do not exist [11].

B. Type of Awareness

There are several kinds of awareness that can be seen in group work. Gutwin et al provides four types of awareness in group work [12]. These four types consist of informal awareness, social awareness, group-structural awareness, and workspace awareness. Informal awareness is the kinds of things that people know when they work together in a face-to-face environment. Social awareness is awareness about the social situation of the group members, i.e., awareness about what they are doing, what they are talking about to someone, etc. Group-structural awareness relates to the knowledge about people's roles and responsibilities, their positions on an issue, their status, and the state of various group processes. Workspace awareness is the collection of up-to-the minute knowledge a person holds about the stage of another's interaction with the workspace. There are other kinds of awareness discussed in the literature, which are organizational awareness and situation awareness. Organizational awareness represents the relationship of people, knowledge of how the group activity fits in with the larger purposes of an organization, their rational for being together and their shared knowledge [13]. Situation awareness is explained as an understanding of the components in the environment at a particular moment in time and space, the comprehension of their meaning and the projection of their status in the near future [14]. The maintenance of social awareness in distributed groups has been explored in CSCW through desktop videoconferencing [15], video tunnels [16], or the mixing of video and computational workspaces to allow eye contact within a work surface [13], [17].

This article has developed an application to support informal cooperation for an online work group and group decision making by using awareness information displayed in a web-based environment that uses the following information: activity, and availability. The activity and availability information appear as a visual display and changes in real-time when the group begins working together. Commitment/ disposition information is captured during collaborative work and summarized when they finish group work. Awareness information used in a web-based GDSS, in this article, is defined as group awareness information.

III. RELATED WORK

Collaborative systems have endeavored to support the accomplishment of tasks. A number of collaborative systems have attempted to build the same atmosphere of causal awareness and informal interaction between people in separate places. These systems utilize a range of techniques that range from symbolic systems through media spaces to support distributed work groups through access to information that supports generate awareness [18]. There are three types of techniques and systems that support awareness: Real Time Systems, 3D Virtual Spaces Systems, and Symbolic Systems [19]. In this section, only the work related to symbolic systems are described because it is the area related to the work reported in this article.

Spring, et al presents an awareness tool in CASCADE (Computer Augmented Support Collaborative Authoring and Document Editing) [19]. CASCADE was designed to allow groups of people to work together on documents. One goal of CASCADE was to reduce the cognitive overhead in the authoring of structured documents by employing a variety of information streams, augmented processes and software tools. An awareness tool in CASCADE presents the user with a set of pictures of group members who are currently using CASCADE. As the group members start and stop sessions, the gallery of pictures is updated to reflect the identity of members who are available. Clicking on a picture starts an interactive talk session with the selected user. A social awareness tool was integrated into a version of CASCADE. The awareness tool

shows the level of user activity, the current focus of their efforts, and their disposition for engagement. The awareness information presented is generated from user activity and tied to individual documents. It is constantly updated based on the activity of group members. The sharpness of the image is a reflection of how active they are. Jongsawat et al presents a prototype of group awareness information in a web-based group decision support system [20]. They proposed and designed three factors that group members use in assessing others socially in an online collaborative work situation. These three factors consist of activity, availability, and commitment/disposition information. They also proposed an experimental design for online collaborative work in order to study how group awareness information impacts the quality of the work effort on a given task, group decision making by the members in the same group and different groups, the communications among group members in the completion of an online collaborative authoring task, the cohesiveness among group members in a web-based group decision support system, and the commitment/disposition to engage each member of the group.

The purpose of this article is to conduct an experiment described in the previous article in order to test the predefined hypothesis set in a field test setting. The details of group awareness information are described in the next session.

IV. Design and Implementation of Group Awareness Information in Web-based GDSS

A. Three factors in Group Awareness Information

There are a variety of factors that people use in assessing others socially in a collaborative work situation. In this research on a Web-based Group Decision Support System, activity and availability are selected as two factors for transforming the captured data into visual data that is displayed in the World Wide Web environment because they appear frequently in the literature. The commitment/disposition information is captured during group work and summarized at the end of the group work task. There are various operational definitions for each of these factors. They are operationally defined in our Web-based Group Decision Support System as follows:

1) Activity information is information about what others in a group are doing or have done. It was operationally defined as the sum of the amount of content that a group member edits in the work space (web page) each time divided by the number of minutes for editing content each time + the sum of the amount of content for each comment that a group member generates for other group members divided by the number of minutes for editing comments each time, See (1). The formula is shown below:

$$\text{Activity} = \sum_{i=1}^{n} \frac{(\text{NoOfContentWord}_i)}{\text{MinContentEdit}_i} + \sum_{j=1}^{m} \frac{(\text{NoOfCommentWord}_j)}{\text{MinCommentEdit}_j} \qquad (1)$$

Note that n is the number of times a group member accesses the web page for editing the contents. m is the is the number of times a group member generates comment(s) to other group members. Both m and n are set to timeout (no count) if a group member accesses the web page for more than five minutes and edits nothing. NoOfContentWord is the number of words (content) a group member edits in the work space. NoOfCommentWord is the number of words/comments a group member generates to other members. MinContentEdit is the number of minute(s) a group member spends in editing the contents in the work space. MinCommentEdit is the number of minute(s) a group member spends in generating each comment. The formula attempts to capture some sense of how active and how engaged, an individual is with respect to group work in a web-based group decision support environment. Activity is defined in this study as a function of the size of the content of a web page, the number of times it was accessed, the number of minutes used when the content was added or edited, and the number and amount of comments that a group member generates. The higher the activity value of a group member, the more active he/she has been doing his or her work.

2) Availability Information is information about who is around and available for others in the group at any point in time. It was operationally defined as the number of minute(s) connected divided by the expected number of minutes connected (determined per task) + a self assessment rating of how busy each group member is + a rating of the delta of availability + a degree of activity, see (2) and (3). The delta factor indicates whether group members are becoming more or less available over a set of time periods. That is, it indicates whether availability is increasing or decreasing. The formula is shown below:

$$\text{Availability} = \frac{\text{MinConnected} + \Delta P + \text{CLR} + \text{ACT}}{\text{ExpMinConnected}} \qquad (2)$$

$$\text{where } \Delta P = \frac{P_n}{\left(\frac{P_i + \ldots + P_{n-2} + P_{n-1} + P_n}{n-1} \right)} \qquad (3)$$

Note that MinConnected is the number of minute(s) that a group member connects to the system to complete a task over a given period. ExpMinConnected is the number of minute(s) that a group member is expected to spend on a task over a given period. Current Life Rating (CLR) is self assessment. Group members rate their current life using a Likert scale of 5 to 1 (very busy, busy, normal, not busy, and comfortable) respectively. ExpMinConnected and CLR are obtained from individuals who fill out a pre-experiment questionnaire that asks about these two variables. ΔP is the number of minutes connected in time n over number of minutes connected in any period of time from i to n for a particular user where Pi is the number of minutes connected in time i (starting period); Pn-2 is number of minutes connected in time n-2; and Pn is number of minutes connected in time n (ending period). ACT is the degree of activity. It is obtained from the calculation of activity shown in the previous formula using a Likert scale of 5 to 1 (not active, less active, fair, active, and very active) respectively. If the availability value is high, it means that a group member is less available for other members because he or she probably has a lot of things to do at the moment and have no room for other tasks.

In social relationships, members use availability information to help them process their interactions in an environment [5]. On one hand, availability of other members in a group can be perceived through their reliability, work ethic, or productivity. If we can rely on a person in our group, we consider that person as an available member. If a person works very hard or more than would be expected, we could say that a person should be available for others. If a person doesn't work very hard, we might think that they would not be available for helping others in completing a task. On the other hand, if a person is working and still has time left, we might also consider that person as an available member. In this case, it is an availability to do more work. If a person is working longer than the expected time to complete a task, we might consider that person to be not available.

3) Commitment/Disposition is defined as information about how willing a group member is to do more work, which includes how he or she views the task, group work, or the members in a group work positively or negatively. Operationally, this value was calculated as a group assessment value + NoOfComment(s) + NoOfResponse(s), see (4) and (5). The formula is shown below:

$$\text{Com./Dis.} = \text{GA} + \text{NoOfComment(s)} + \text{NoOfResponse(s)} \quad (4)$$

$$\text{GA} = \sum_{i=1}^{n} \frac{(\text{GSi})(\text{wi}) * 100}{n} \quad (5)$$

Note that GA is Group Assessment. It is calculated as shown in (5). GS is a group score that is generated by each group member by rating his or her group for commitment/disposition for engagement using a scale from 1 to 5 (lowest, low, medium, high, and highest). Wi is a uniform distribution of the weight. For example, if the number of members in group is 5 then w1 is equal to 0.2, which is also equal to w2, w3, w4, and w5. The value n is the number of members in group. There are questions in the pre- and post-questionnaires about how users feel toward each section in a given tasks, and how they feel about other group members. NoOfComment(s) is number of comments that a group member generates to other members during a working period. NoOfResponse(s) is number of responses, answers, or suggestions that a group member posts to other members in the chat room during a working period. The irrelevant comments and responses to the task are eliminated. If a group member generates more comments and responses to others and/or has a positive attitude towards the task or other members in the group, he or she tends to have a high commitment for accomplishing a group task.

This information endeavors to capture the feelings of a person toward other members, the behavior of the person, a particular content aspect in the work space, and how much a person contributes to a group task using the number of comments and responses in group work, which have been made, by the members in the same group. This information is not shown as the visual display during group work. It is concluded at the end.

B. Web-based GDSS

This article presents a group decision support system with group awareness information in a web-based environment called a web-based GDSS. It is designed and implemented by following the Nominal Group Technique (NGT). The NGT technique is a structured decision making technique widely used both in industry and academia as a tool to aid in planning and decision-making processes [22]. Paulus' cognitive theory of group creativity suggests conditions under which cognitive stimulation can be observed in groups. The theory suggests that sharing ideas within a group stimulates additional generation and association of ideas. The Nominal Group Technique (NGT) provides an advantageous environment to stimulate creativity since it allows for the silent generation of ideas, which then are shared by the group. The technique has been recognized as a way to equalize participation, tolerate conflicting ideas and stimulate the generation of ideas by sharing them with the group [23]. When groups generate ideas using brainstorming, the competing demands of generating their own ideas and also processing the ideas of the others has been observed to divide the participants' attention [22], [24]. Paulus and Yang recognize that if, after brainstorming, individuals are provided with an opportunity to generate additional ideas on their own; the impact of cognitive stimulation may become more evident [25]. Nominal Group Technique seems to provide the appropriate environment for cognitive stimulation while encouraging creativity [23]. The NGT session in web-based GDSS consists of the following phases:

The NGT session in web-based GDSS consists of the following phases:

- Presentation of the task statement
- Fill out a pre-experiment questionnaire
- Idea generation
- Round robin (optional in this research)
- Clarification or evaluation of each idea/solution
- Voting and ranking all ideas/solutions
- Final discussion (optional in this research)
- Fill out a post-experiment questionnaire

In the web-based GDSS used for this experiment, a script was created so that all sessions would be as consistent as possible. A web site was specifically designed to conduct the NGT group work through a computer (web browser). Process support for the participants was provided through the site by instantaneous instructions on each step of the process. The web site has three main features, a built-in pre-session questionnaire, working area session and tools (edit/ ranking pages, comment/ communication tools), and a built in post-session questionnaires. Initially, group members are asked to complete the pre-experiment questionnaire when they enter the web site. It takes twenty minutes to complete this session. Once the questionnaire is completed, they are directed onto the second part, which is a working area session, starting with instructions for group work. The group facilitator utilizes one and half hour for explaining the instructions and demonstrating the application in the classroom. Next, the decision process begins with the idea generation phase. This phase takes one month. During this phase, they individually login to their

session with the given username and password and spend their time generating ideas to perform their given tasks on the individual web page. Next, they enter the brainstorming phase for three months. In this phase, they are allowed to communicate with each other by using a chat room (interaction screen) provided for each group. They can ask questions and discuss ideas with other members in the same group. They can collaborate or help each other to solve the given task and generate more ideas. Each group member can also use a comment tool for sending comments or recommendations to other members in the same group. Next, they enter the clarification phase for three weeks. All members have time to refine their task by working in their own session such as the option to clarify, reword, add or group the ideas if needed. During this phase, every member spends most of the time trying to improve their individual tasks. The chat room is not available during this phase. Then, each member has to select their preferred solutions to be scored by the other group members in the same group. Next, they are directed to the scoring and ranking phase for thirty minutes in the last week of the experiment. They are asked to give a score for the other group member's listed solutions. An online evaluation form is provided to an individual. Each item in the form uses a scale of 1 to 10 (one being worst and ten being the best). He or she cannot assign a score to himself/herself. The total score for each member is calculated and recorded in the database. The solutions from five members in the same group are collected and used as a representative solution for the group. The group's solutions are further sent to three judges to be scored after finishing the experiment. Finally, they fill out the post-session questionnaire. It takes thirty minutes to complete this last session. Pre- and post session questionnaires are used to capture some dependent variables from individuals. Some variables from the pre-session questionnaires such as current life rating (CLR) and expected minutes connected are obtained in order to generate availability information. Some variables from the post-session questionnaires are used for making conclusions for hypotheses.

The members in the group that are allowed to see awareness information can see a visual display of group awareness information by clicking the link anytime during their work (see figure 1). The activity and availability information are automatically updated when the user's information has been changed. The working period for each session is specified in an instruction. Time limitation is assigned for each session.

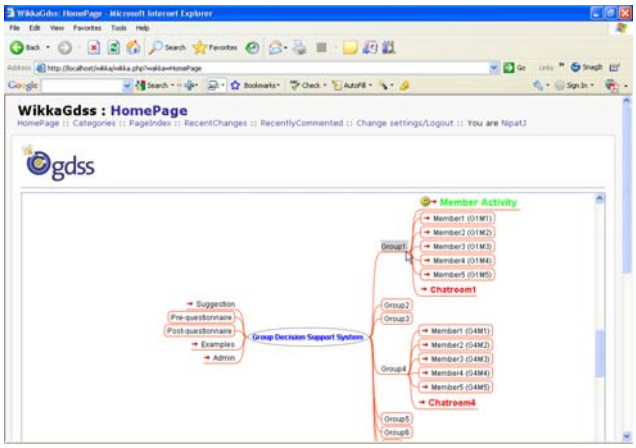

Figure 1. Member Activity (Group Awareness Information) Link in Web-Based GDSS.

C. *The Group Awareness Information as Visual Interface in Web-based GDSS*

Given the operational definitions, there are a variety of ways to present group awareness information. In the literature, Spring presents a social awareness tool in CASCADE that shows the level of user activity, the current focus of their efforts, and their disposition to engagement [19]. In his work, activity information is represented by the fuzziness of an image. Pictures of a user are sharp if the activity is high and fuzzy if the activity is low. The resolution is relative to all members in a team for a particular document. Availability information is shown by a slide bar with the indicator moved to the right indicating higher availability. Commitment/ Disposition information is depicted by using color. Pictures of users will be green if the disposition value is positive and red if negative. All kinds of information shown above are presented in real-time collaborative work on CASCADE. The findings in his study about awareness tools are contrary to the existing theory. His study expected that the group with awareness tools could produce better quality work for a group task. In fact, the awareness tools had a negative effect on their performance. Participants gave comments at the end of the experiment that the design of the awareness tool was difficult to understand. Furthermore, they reported that participants may not have felt attached to their pictures in the awareness tool. It may even be the case that the functional use of the simpler awareness tools would lead to a better performance in group tasks.

His experimental results are incorporated into our study for improving the visual display and finding ways to better represent the different kinds of awareness information in a WWW environment. Given a desire to code the group awareness information, a minimalist visual display was chosen. Using small smiley icons with a short explanation were considered. Small smiley icons were chosen because people are familiar with them and using icons plus a short explanation people can understand them easily. The visual display of group awareness information in a web-based GDSS for individuals and groups is shown in figure 2 and figure 3, respectively. The screenshots of a comment tool and chat room are shown in figure 4 and figure 5, respectively.

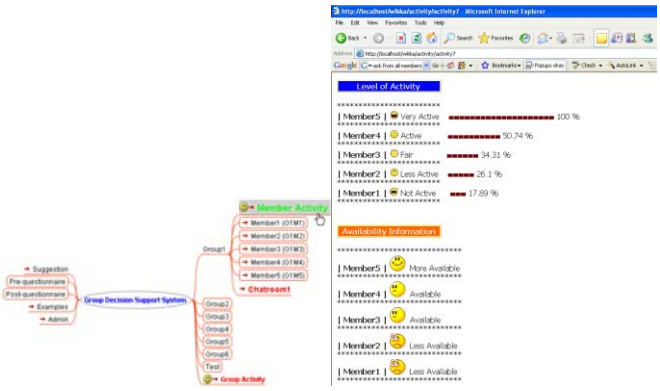

Figure 2. The Visual Display of Group Awareness Information in Web-Based GDSS.

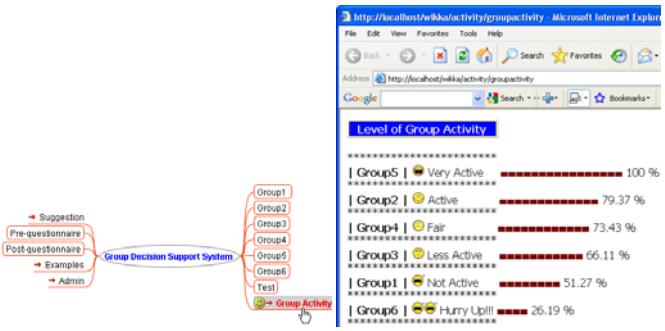

Figure 3. The Visual Display of Group Awareness Information in Web-Based GDSS for all Six Groups.

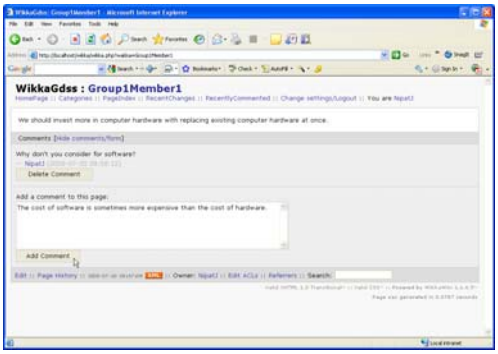

Figure 4. Screenshot of a Comment Tool in Web-Based GDSS.

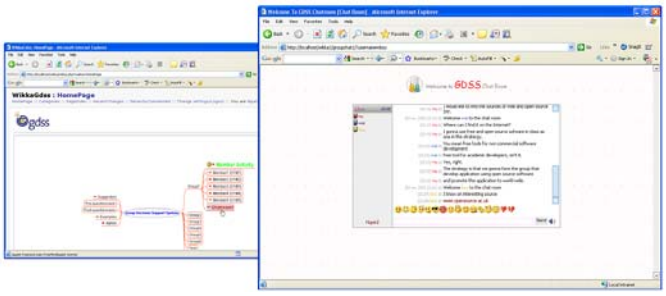

Figure 5. Screenshot of an Online Chat Room in Web-Based GDSS.

V. METHODOLOGY

A field test setting experiment was undertaken to examine the effects of the use of a web-based group decision making technique with and without group awareness information. The main purpose of this study was to analyze the following factors in a web-based GDSS with and without group awareness information: the quality of the work effort and a given task, group decision making by the members in the same group and different groups, the communications between group members for the completion of an online collaborative authoring task, the cohesiveness among team members in a web-based GDSS, and the composition/disposition of engagement for social group work.

A. Participations

Thirty of 1st year graduate students, who took the database course in the information technology department at Siam University, were recruited to participate in the experiments. They were randomly assigned to sub-groups of five members in each group. Six sub-groups were formed. The first three groups (group 1, 2, and 3) could see group awareness information and the last three groups (group 4, 5, and 6) could not see any group awareness information. Demographic data were collected on age, gender and the background of the participants. Specifically, ages ranged from 23 to 37 years old. With respect to gender distribution, 40% of the participants were female and 60% male.

B. Materials

Participants in the experiment used their own personal computer with a standard web browser to perform given task in web-based GDSS. The group facilitator and participants mainly communicated each other via e-mail and web board systems. The provided tools on web-based GDSS such as an online chat room and a comment system were provided to the participants for communication during the experiment. The web-based GDSS application was developed using a wiki-style, WikkaWiki.

C. Research Questions

The first research question was established based on the assumption that the group awareness information should stimulate the group members to generate more ideas, comments, recommendations, communications, and finally produce a better quality task result than the group members without group awareness information. The mean quality score on a task produced by group member with group awareness information should be significantly higher than the mean score on a task produced by a group member without group awareness information.

Question 1: Do group members achieve a higher quality score for a given task in a web-based GDSS with group awareness information than they do without group awareness information?

The second research question anticipated that the group awareness information should affect group decision making by members in the same group. The group members with higher activity and availability scores should obtain a higher voting

score for their individual task or solutions from the other members in the same group.

Question 2: Does group awareness information effect group decision making by the members in the same group?

The third research question anticipated that group awareness information representing the group should affect the members in different groups in the sense of competing with other groups that are more active or obtain a higher activity value than they do.

Question 3: Does group awareness information affect the members in different groups in the sense of competing or overcoming other groups that are more active or obtain a higher activity value than they do for the same given task?

The group awareness information should stimulate group members to produce a higher number of communications in the same group. The number of communications generated is expected to be increased because of group awareness information.

Question 4: Do group members produce a higher number of communications in a web-based GDSS with group awareness information than they do without group awareness information?

The cohesiveness among group members is expected to be higher because of group awareness information. When the number of communications in a group increases, the cohesiveness among group members should also increase.

Question 5: Do group members achieve higher cohesiveness among themselves for a given task in a web-based GDSS with group awareness information than they do without group awareness information?

Lastly, the commitment/ disposition for the engagement of each member of the group is expected to be higher because of group awareness information. The group awareness information should stimulate individuals to have a positive attitude toward the task or other members in the group. Finally, they tend to have a higher commitment for accomplishing a group task and should be willing to do more work.

Question 6: Do group members achieve higher commitment /disposition of engagement for accomplishing a group task in a web-based GDSS with group awareness information than they do without group awareness information?

D. The Experimental Task Statement

The task statement for each group was defined as follows: 'analyze and design the entity relationship diagram for the investment fund management method and system and show its prototype implementation for such a selected investment fund management system". All participants (group member 1, 2, 3, 4, and 5 for each group) were asked to solve the same given task on web-based GDSS. Finally, each group had to present their final group solutions.

VI. THE STUDY AND RESULTS

In assessing the impact of group decision making with and without group awareness information, we studied both a controlled experimental setting and in a field test. The controlled experiment has been conducted, summarized, and reported before. This research presented the results obtained form the experiment that has been conducted in a field test setting. We believe that perceptions or reactions of other individuals in group work would be developed over a period of months or semesters.

The goal of the study was to measure the impact of group awareness information on the solutions for the group task, group decision making, number of communications, the amount of cohesiveness among group members, and the commitment/disposition for engagement. The results of the study are as follows.

Question 1: The quality of group solutions was evaluated through three independent reviews conducted by outside judges.

The mean quality score of a solution produced by groups working with group awareness information was higher (mean = 26.666, SD = 7.158), than it was for the groups working without the group awareness information (mean = 21.444, SD = 3.539). Using an upper one-sided t-test, the calculated t-statistic = 1.962 exceeds the critical value $t_{16,\ 0.05} = 1.746$, the H_0 was rejected at a level of significance $\alpha = 0.05$.

The result for research question 1 was statistically significant and we concluded that the group members with group awareness information achieve a higher quality for a given task in a web-based GDSS with group awareness information than they do without group awareness information.

Question 2: The results for research question 2 were made using two different approaches. Both of them were taken into consideration in arriving at a conclusion for this research question. First, it is the relationship between the activity/availability scores and the total score for the task solutions that they receive from other members in the same group. Second, a conclusion was determined from the question in the post-experiment questionnaire, "Do the activity and availability scores effect your decision making for giving a score to the other member's solutions in the same group?" using scale of 1 to 5 (1 being lowest impact and 5 highest impact).

Using the first approach, the experimental data shows that some group members who obtained higher activity and availability scores received lower scores for the solutions they produced (evaluated by other group members) than the other members who obtained lower activity and availability scores.

In the second approach, the mean score obtained from post-experiment questionnaire was 2.25 (S.D. = 1.258), which was lower than the average.

The results from the two approaches were consistent with each other. The conclusion was that group awareness information did not affect group decision making by the members in the same group.

Question 3: The conclusion for research question 3 was made from the questions in the post-experiment questionnaire, "Does group awareness information representing for the group impact on you during group work? (1)" and "Would you like to increase your effort to solve the given task if you see the

information that other groups are more active? (2)" using scale of 1 to 5 (1 being lowest impact and 5 highest impact).

The mean voting score from both questions of the groups produced by each group member without group awareness information was significantly higher (mean = 3.133, SD = 1.966), than the mean voting score from both questions of groups produced by each group member with group awareness information (mean = 2.9, SD = 1.87). Using upper one-sided t-test, the calculated t-statistic = 0.799 does not exceeds the critical value $t_{60,\ 0.05} = 1.67$, the H_0 was accepted at level of significance $\alpha = 0.05$.

The conclusion was that the group awareness information representing a group did not affect the members in different groups in the sense of competing or overcoming other groups that are more active or obtain higher activity values than they do for the same given task.

Question 4: The definition of communication in this research project is defined as the number of activities or interactions such as posting a comment/recommendation and asking/answering questions using the provided comment tool and chat room that the group members use to respond to each other. The research question 4 is concluded using two approaches. First, the number of communications is captured during group work. The irrelevant information such as greeting messages was not counted. Second, it is made based on the question in the post-experiment questionnaire, "Does group awareness information impact on you to communicate more with other members during group work?". This question is prepared for groups working with group awareness information only.

Based on the first approach, the mean number of communications of groups with group awareness information was higher than in groups working without group awareness information with a mean average of 62.333 (SD = 13.051) and 60.666 (SD = 11.372), respectively. Using an upper one-sided t-test, the calculated t-statistic = 0.842 does not exceeds the critical value $t_{6,\ 0.05} = 1.943$, the H_0 was accepted at level of significance $\alpha = 0.05$.

Based on the second approach, the average score of the question in the post-experiment questionnaire for group 1, 2, and 3 in both sessions was 2.333 (SD = 0.975), which was lower than the average.

There was no significant difference between the mean number of communications occurring among group members with and without group awareness information even if the mean number of communications of groups with group awareness information was higher than in groups working without group awareness information. The results from the two approaches were consistent with each other.

Question 5: The results for this research question were made from the pre and post-experiment questionnaires. The questions, "Do you like to work with other members in group to solve a given task?" and "Do you feel a positive attitude to the task or other members in the group when you work together?" (Asked in both pre and post questionnaire) were asked. The average scores from pre and post are calculated.

The mean value for cohesiveness occurring among group members with group awareness information was significantly higher (mean = 3.666, SD = 1.556), than the mean number for cohesiveness occurring among group members with group awareness information (mean = 3.333, SD = 2.103). Using an upper one-sided t-test, the calculated t-statistic = 1.735 exceeds the critical value $t_{120,\ 0.05} = 1.66$, the H_0 was rejected at a level of significance $\alpha = 0.05$.

From the results of the study, group awareness information affects cohesiveness among group members in a web-based GDSS. Even through there was no significant difference between the mean number of communications occurring among group members with and without group awareness information but the group members with group awareness information tend to develop much cohesiveness among themselves.

Question 6: The results for the last research question were determined using two approaches. First, the commitment/disposition value was calculated using the formula defined in equation (4) and (5). Second, it was made from the post-experiment questionnaire. The question, "How much the rating score do you give to the group for commitment/ disposition for engagement to accomplish a group task?" was asked.

Based on the first approach, the mean number of commitment/disposition occurring among group members with group awareness information was significantly higher (mean = 182.333, SD = 11.846), than the mean number of commitment/disposition occurring among group members without group awareness information (mean = 160.333, SD = 13.428). Using upper one-sided t-test, the calculated t-statistic = 2.128 exceeds the critical value $t_{6,\ 0.05} = 1.943$, the H_0 was rejected at level of significance $\alpha = 0.05$.

Using the second approach, the rating score of the group with group awareness information was slightly higher than in groups working without group awareness information with a mean average of 3.8 (SD = 1.082) and 3.0 (SD = 1.133), respectively. Using upper one-sided t-test, the calculated t-statistic = 1.977 exceeds the critical value $t_{30,\ 0.05} = 1.697$, the H_0 was rejected at level of significance $\alpha = 0.05$.

The conclusion was significant in that it showed that the groups with group awareness information had higher commitment/disposition for engagement than in groups working without group awareness information.

VII. Conclusion

In this study, we gathered data regarding processes and outcomes from groups using the Nominal Group Technique in two different settings: groups working with and without group awareness information system. The group awareness information was represented as a visual display during group work in a web-based GDSS. The group awareness information was operationally defined in a Web-based Group Decision Support System as follows: activity, availability, and composition/disposition. These values were captured from each group member's behavior during online collaborative work while solving a given task. The activity and availability

values were captured and presented to the group members in real-time and the composition/disposition value was captured and summarized at the end of the experiment. The goal of the study was to measure the impact of group awareness information in a web-based GDSS on the following factors: (1) the quality for a group task, (2) group decision making by the members in the same group, (3) the affect on members in different groups in the sense of competing or overcoming other groups that are more active or obtained a higher activity value than they do in the same given task, (4) the number of communications for the groups with and without group awareness information, (5) the cohesiveness among group members, and (6) the commitment/ disposition for engagement to accomplish a group task.

The results of this field study were: (1) the group members with group awareness information achieved statistically significant quality scores for a given task in a web-based GDSS than they do without group awareness information, (2) the group awareness information didn't affect group decision making by the members in the same group, (3) the group awareness information presented to the group did not affect the members in different groups in the sense of competing or overcoming other groups that were more active or obtained a higher activity value than they do in the same given task, (4) there was no significant difference between the mean number of communications occurring among group members with and without group awareness information, (5) group awareness information affected cohesiveness among group members in a web-based GDSS, and (6) the groups with group awareness information had a higher commitment/disposition for engagement than in groups working without group awareness information.

This study has increased our understanding of the impact of group awareness information in a web-based GDSS. Group awareness information provides useful information for improving the quality of collaborative work in a web-based GDSS. However, this study found limited support for the use of group awareness information to increase the quality of group decision making and the number of communications occurring among group members. In future research based on this study, we intend to summarize the comparison of group awareness information in a web-based GDSS between a controlled experiment and a field test setting.

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