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Multi-Criteria Group Decision Making with Private and Shared Criteria: An Experiment

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Abstract. Collective decision processes remain a common management approach in most organizations. In such processes, it seems important to offer participants the opportunity to confront the differences in their points of view. To this end, cognitive and technical tools are required that facilitate the sharing of individuals' reasoning and preferences, but at the same time allow them to keep some information and attitudes to themselves. The aim of our study is to assess whether, in the multi-criteria approach to problem structuring, decision-makers can be comfortable using shared criteria in addition to private criteria. For this purpose, an exploratory experiment with student subjects was conducted using the Group Decision Support System, GRUS.

Keywords: GDSS, Multi-Criteria Group Decision Making, Private Criteria, Public Criteria.

1 Introduction

In large organizations, the vast majority of decisions are taken after extensive consultations involving numerous individuals, rather than by individual decision makers [1]. According to Smoliar and Sprague [2], decision making in organizations generally involves the interaction of several actors. This interaction includes communication of information, but its main aim is to enable the decision makers to come to a shared understanding, thereby assisting them at achieving a coordinated solution to the problem at hand.

The process of group decision making has been analyzed from a number of perspectives. Recently, Zaraté [3] suggested that the increasing complexity of organizations, and the use of Information and Communication Technologies to support them, require decision processes to be modified. On the organizational level, processes now involve more actors with greater amounts of responsibility, while at the individual level, decision makers face more demands on their cognitive processes; they not only face greater quantities of information, but must also make sense of it rapidly. A new kind of Cooperative Decision Process is now needed.

To support a group engaged in decision making, Macharis et al [4] introduced a methodology based on the Multiple Criteria paradigm through the PROMETHEE methodology. They propose that each decision maker create his or her own performance matrix by determining his or her own individual values. Then a global evaluation of each alternative is performed using a weighted sum aggregation technique. Decision makers' weights may be equal or different. One benefit of this structure is the ability to conduct a stakeholder-level sensitivity analysis. Nevertheless, the proposed system does not permit the decision makers to share their preferences with others, or to co-build a decision.

In a collective decision framework, decision makers must balance their own attitudes and preferences with the goal of building common preferences and consensus within the group. The purpose of this paper is to investigate whether decision makers can feel comfortable making decisions that integrate common and individual preferences. We conducted an experiment based on the multi-criteria Group Decision Support System, GRoUp Support (GRUS). This experiment is an exploratory research. The aim was to explore parameters that highlight the advantages and disadvantages of a multi-criteria Group Decision process. In practice, are the advantages noticeable, and under what conditions? We also wish to assess whether participants can perceive the advantages of the group multi-criteria approach to decision-making.

This paper is structured as follows. The GRUS system is described in section 2. Then the Research Questions of our study are set out in section 3, and the experiment is described. Section 4 gives the experimental results and analyzes them, and section 5 discusses the implications of the results for the hypotheses in section 3. Finally, in section 6, we give concluding remarks and perspectives on this work.

2 GRoUp Support: The GRUS System

GRUS, a free web platform available at http://www.irit.fr/GRUS, can support several kinds of meetings: synchronous, asynchronous, distributed or face-to-face. Sometimes, additional components are required; for example, a distributed/asynchronous decision process is managed by a facilitator as a classical project, with agenda, deadlines, etc. GRUS is protected by a login and a password, available from the authors upon request.

GRUS is designed as a toolbox and implemented in Grails, a framework based on Groovy, a very high level language similar to Python or Ruby. Groovy can be compiled to a Java Virtual Machine bytecode and can interoperate with other java codes or libraries. For more details, see [5].

GRUS is designed to support different types of users, including designers of collaborative tools (application developers), designers of collaborative processes (collaboration engineers), session facilitators and decision makers (users of GRUS). It offers the basic services commonly available in Group Decision Support, such as definition/design of a group decision process, both static and dynamic way; management (add, modify, delete, etc.) of collaborative tools; management of automatic reporting in PDF format, etc. It is conceived as a toolbox for Collaborative Decision Processes, and includes a Brainstorming tool, a Clustering tool, multi-criteria Analysis, a Voting tool, a Consensus tool, and a Reporting tool.

Using the multi-criteria tools, users can define criteria and alternatives, and give their own assessments of the performance of each alternative on each criterion, creating a performance matrix. Each assessment is on a scale from 0 to 20. Decision makers may also indicate their own (individual) preferences for the weight of each criterion.

In order to enter his or her own preferences, a decision maker must enter a so-called suitability function, including an indifference threshold. In this way, the user's interpretation of each criterion can be taken into account. Finally, each decision maker's assessment of the dependencies between pairs of criteria can also be entered. Again, these dependencies are marked by each decision maker on a scale from 0 to 20.

Two aggregation techniques are implemented in the GRUS system. The first aggregation methodology is the weighted sum [6], which ignores any possible dependencies among criteria. The second aggregation methodology is the Choquet Integral [7], which does reflect dependencies among pairs of criteria.

3 The Experiment

3.1 Research Questions

Ideally, a group decision-making process includes much sharing of information as participants develop a common preference, leading to a good decision. Thanks to discussion, a better knowledge of the alternatives and the matches between preferences and alternatives is then possible. But participants may often simply announce their preferred alternative, without providing arguments about its appropriateness to solve the problem at hand. If so, the decision process does not contribute to any deeper understanding of the problem, and the decision does not benefit from being taken by a group [8]. Moreover, open sharing and extensive discussion are seldom practicable, first because participants have personal information or considerations that they do not (for reasons of strategy or privacy) reveal. Secondly, some aspects of individuals' preferences may not be crystal clear to themselves.

Thus, it is common that the result of a group decision-making process is based on a mix of objective and subjective reasoning. Recognizing this feature, Sibertin-Blanc and Zaraté [9] proposed a methodology distinguishing collective criteria and individual criteria, defined as follows:

- A criterion is *collective* if the group participants agree not only on its relevance, but also on the score of each alternative on this criterion;

- A criterion is *individual* if it is considered relevant by one (or several, but not all) participant, or if the participants do not agree on the scores of alternatives on this criterion.

The collective criteria constitute to the objective part of the group's assessment, while individual criteria are its subjective part.

Research Question 1: In the design of a collaborative decision process, participants benefit from the availability of both private and common criteria.

In order to guarantee group cohesion and consistency, it is necessary to find a balance between the individual part of the problem, i.e. the private criteria, and the collective part, i.e. the common criteria. On the other hand, it seems to us that if the number of private criteria is greater than the number of common criteria the decision is not really a group decision, but rather a collection of individual decisions.

Research Question 2: In a collaborative decision making process, the number of private criteria should at most equal the number of common criteria.

The role of Group Decision Support Systems is to support collaborative decision processes. Often a GDSS requires group facilitation, defined as a process in which a person acceptable to all members of the group intervenes to improve the group's identification and solution of problems, and the decisions it makes [10]. Facilitation is a dynamic process that involves managing relationships between people, tasks, and technology, as well as structuring tasks and contributing to the effective accomplishment of the intended outcomes.

Ackermann and Eden [11] found that facilitation helped groups to contribute freely to the discussion, to concentrate on the task, to sustain interest and motivation to solve the problem, to review progress and to address complicated issues rather than ignore them. A further task of facilitation is to engage the group in creativity and problem formulation techniques and to help it bring structure to the issues it faces [12]. Facilitators attend to the process of decision making, while the decision makers concentrate on the issues themselves.

Can facilitation be automatic? It has been argued that automatic facilitation enriches a GDSS as it guides decision makers toward successful structuring and execution of the decision making process [13]. According to [14], an electronic facilitator should execute four functions: (1) provide technical support by initiating and terminating specific software tools; (2) chair the meeting, maintaining and updating the agenda; (3) assist in agenda planning; and finally (4) provide organizational continuity, setting rules and maintaining an organizational repository.

Nevertheless, it seems difficult to program a process leading to insightful and creative decisions. Can a GDSS work well without a human facilitator?

Research Question 3: GDSS use remains difficult without a human facilitator.

3.2 Description

The experiment was conducted at Toulouse Capitole 1 University. One Master-level computer science class comprising 14 students was selected to participate. Three groups were created, including 4, 4 and 6 participants respectively. Each group worked independently, in a one-session meeting of 90 minutes. After the decision process, each participant responded to a questionnaire composed of seven questions, five about the common versus private criteria (Research Questions 1 and 2) and two about facilitation (Research Question 3).

The case-study decision problem was presented to each group is described below.

"You are member of the Administrative Committee of the Play-On-Line Company. This company develops Software Games. It includes 150 collaborators represented as follows:

- 80% Computer Engineers
- 15% Business Staff
- 5% Administrative Staff.

During a previous meeting, the Board decided to buy new mobile phones for all collaborators (the whole company). The use of the phones will not be the same for the three groups of collaborators. The computer engineers need to test the software as it

is developed, on every operating system (Android, iPhone, etc.); the business staff will demonstrate the software to potential clients (and need large screens, for example). The administrative needs are simpler and more basic, such as communication (email, text, telephone, etc.).

The aim of today's meeting is to make together a decision about the best solution for Play-on-Line. The budget is strictly limited, so costs must be minimized. In order to satisfy the requirements of all stakeholders, your group must think up several solutions or scenarios but you must remember that company survival, from a financial point of view, is mandatory.

You can, for example, decide to buy the same Smartphones for everybody, or you can buy different models of smartphones for different collaborators, including some to be used only for testing. The technical characteristics and prices of five preselected Smartphones are given in the attached documents.

First, you have to define the set of criteria to be used (4-5) to solve this problem, and identify several alternatives (4-5). One alternative is defined as a combination of several smartphones, for example: 80% of Type A + 20% of Type B. You will be guided by the facilitator, and then you will enter in the GRUS system your own preferences used for calculating the group decision".

Each group was required to find 4-5 criteria and 4-5 alternatives, in order to restrict each session to 90 minutes. If the number of criteria and alternatives were decided by the group, we would not have been able to control the time of each session.

Using the GRUS system under the guidance of a human facilitator, the following process was applied:

- Brainstorming: Criteria and Alternatives are generated electronically. Each decision maker expresses himself or herself anonymously.
- Clustering: The number of criteria and the number of alternatives are reduced to 4—5. This step is conducted by the facilitator orally. Decision makers express themselves aloud in order to categorize all the ideas. The facilitator then categorizes the criteria and alternatives until the target numbers of criteria and alternatives (4-5) are achieved.
- Multi-criteria Evaluation: Decision makers give their own preferences on a scale to 0 to 20 for the performance of each alternative on each criterion. They also decide the weight of each criterion and the way that the criterion is to be interpreted (the suitability function – essentially a threshold score below which performance differences were ignored). Pairwise dependencies among criteria were also specified.
- Direct Vote: For this step the facilitator shows the results of the Multi-Criteria analysis. This result integrates all preferences given by all users and the results obtained by two ranking techniques: weighted sum and Choquet

Integral, producing two total orders. A discussion is then initiated by the facilitator in order to classify all alternatives into three categories: A (Kept), C (Not Kept), and B (Feasible but uncertain). A "Kept" alternative will be recommended by the group, while any feasible alternatives must be discussed further.

- Conclusion: Following the previous step, the facilitator proposes the set of kept alternatives as the conclusion of the meeting. If the group must decide on only one alternative, it is still possible to go back to the step Multi-Criteria evaluation in order to refine the solution.
- Report: The facilitator generates a report of the meeting as a pdf file.

4 Results

Each of the three groups agreed on four criteria, as shown in Table 1. Each group identified four alternatives (not shown).

FIX SPACING

Table 1. Group sessions

Group	Number of Participants	Criteria Selected	Number of Alternatives Identified
1	4	Price Operating System Communication Autonomy & Battery Capacity RAM	4
2	4	Price Battery Communication Operating System	4
3	6	Price Autonomy RAM Handling	4

The survey results for all groups are summarized and discussed next.

4.1 Survey Results: Common vs. Private Criteria

The questionnaire contained five questions about whether the decision makers would feel comfortable using only common criteria. The participants' answered on a scale including 4 degrees plus one response for those who have no opinion: Completely agree, Rather agree, Rather not agree, Not at all agree, Without opinion.

Question 1: Do you think it is difficult for the group to find a set of shared criteria?

No participant chose "No opinion." A large majority agreed that it is difficult for a group to find shared criteria, as shown in Figure 1.

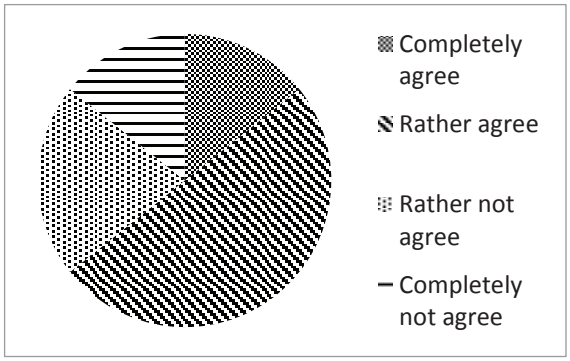

Fig. 1. Difficulty of finding shared criteria

Question 2: Do you think that group size makes it difficult for the group to find shared criteria?

Every participant reported an opinion. A large majority agreed that group size influences the group's ability to find shared criteria, as shown in Figure 2.

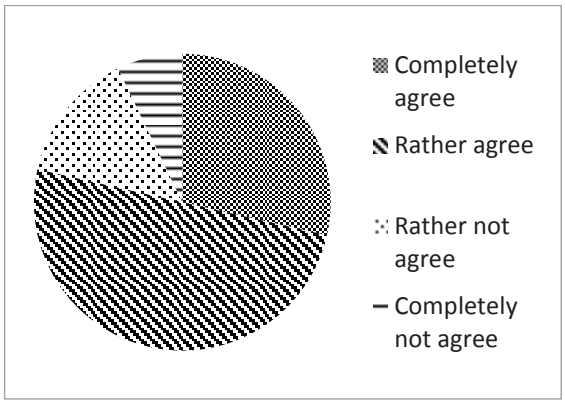

Fig. 2. Size of group influences ability to find shared criteria

Question 3: Do you think it should be mandatory for all group members to use the same criteria?

Again, every participant reported an opinion. A majority agreed that it should be mandatory for the group to work with a common set of criteria, as shown in Figure 3.

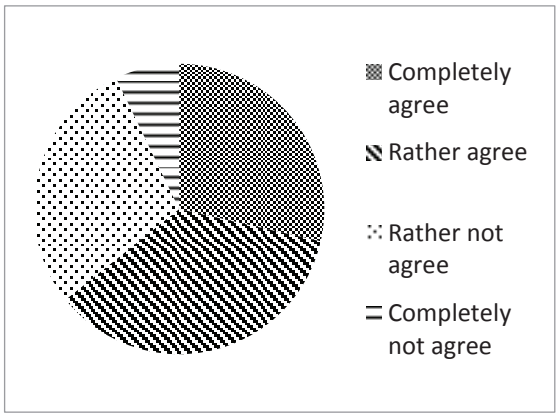

Fig. 3. Group members should use same criteria

Question 4: Is it better to work with shared criteria in addition to private criteria for individual decision makers?

Every participant reported an opinion. A large majority felt that using private criteria would help decision makers, as shown in Figure 4.

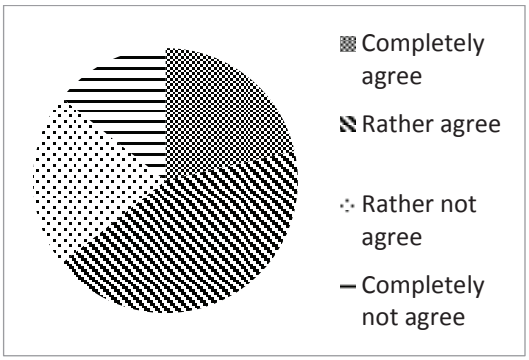

Fig. 4. Use of private criteria

Question 5: Do you think that the number of private criteria for each decision maker should be at least as great as the number of shared criteria?

Every participant offered an opinion. The results were balanced; half of the respondents supported equal numbers of private and shared criteria. Of the remainder, slightly more than half suggested that the number of private criteria should exceed the number of public criteria. The results are shown in Figure 5.

Fig. 5. Number of private criteria equal to number of shared criteria

4.2 Survey Results: Facilitation

The participants were asked two questions about the facilitation process. Their responses were on a scale including 4 degrees, plus one level for those who have no opinion: Completely agree, Rather agree, Rather not agree, Not at all agree, Without opinion.

Question 6: Do you think that GRUS should be used without a facilitator?

Every participant reported an opinion. A small majority agreed that the system could be used without a facilitator, as shown in Figure 6.

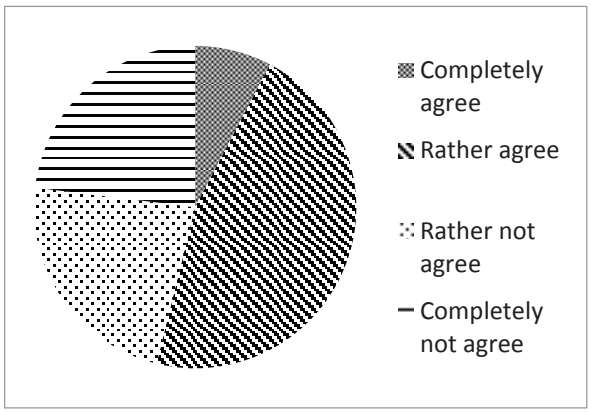

Fig. 6. Use of the system without facilitator

Question 7: Do you think that a decision process using the GRUS system is enough to support a group decision meeting?

No participant completely agreed, but a substantial majority of those with an opinion agreed that the system could be used with the work process it incorporates, as shown in Figure 7.

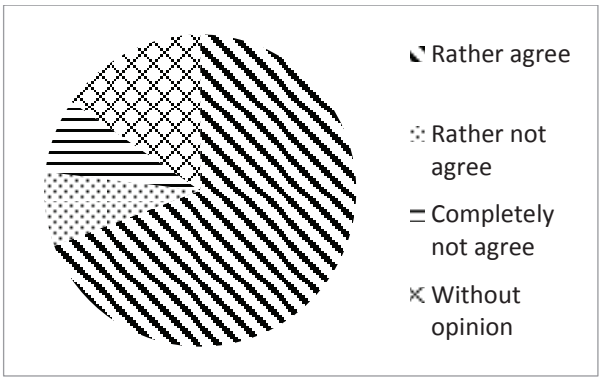

Fig. 7. Use of GRUS with no additional work process

5 Discussion

The Research Questions were assessed in light of the results obtained in the survey.

Research Question 1: In the design of a collaborative decision process, participants benefit from the availability of both private and common criteria.

Most participants find it difficult to identify common criteria (see Figure 1) and agree that the size of the group influences its ability to find common criteria (see Figure 2). Thus, the participants were aware that it is difficult for everyone to define the problem in the same way. From Figure 3 and 4 we see that a small majority of the participants agree that the group may use only shared criteria, but that a large majority sees some private criteria as appropriate. Following these results we conclude that the Research Question 1 is satisfied.

Following this first Research Question, the question is to determine the number of criteria to be used and the proportion of private and common criteria.

Research Question 2: In a collaborative decision making process, the number of private criteria should at most equal the number of common criteria.

As shown in figure 5, half of the respondents feel that the number of private criteria should equal the number of common criteria. But the remaining respondents split almost equally between larger and smaller. The survey results suggest – see figures 3 and 4 – that the participants are comfortable with both common and private criteria, when they are in roughly the same proportions. We conclude that the Research Question 2 is weakly verified.

GDSS use normally involves a facilitator, who may be replaced by a computer system. The next Research Question aims to assess whether the participants feel that it is a better option.

Research Question 3: GDSS use remains difficult without a human facilitator.

Figures 6 and 7 show that the participants appreciate the contribution of a human facilitator, but believe that an automated system can help too. So we cannot draw any conclusions from our survey about the status of Research Question 3. We can only say that if an automated process is implemented to support the group, it could help, but that a human facilitator may also be helpful.

6 Concluding Remarks and Perspectives

Group decisions can be complex and may involve a large degree of conflict. Participants may feel dissatisfied because their wishes and views were not properly considered. They may not be motivated to participate because of an unwillingness, for strategic or privacy reasons, to reveal their assessment of the decision problem. Our view is that the use of both private and common criteria in Multi-Criteria Group Decisions can improve both participation and satisfaction.

Our aim is to study the use of private criteria in a group decision making process. This is only a preliminary study. It is obvious that the quality of the choices made by groups, as well as the range of alternatives and criteria that they generate, must still be studied in order to draw stronger conclusions about the potential contribution of private criteria to a group decision.

This study aimed to test the effects of using private and common criteria in group decisions and it is an exploratory work. This is the first step of a more global experiment including more participants. Clearly our experiments and surveys involved so few participants that no statistical significance can be attributed to our conclusions. In the future, we aim to involve more participants in order to deny or confirm our first results.

The results addressed certain factors that require careful consideration in the design of group decision processes and group decision support. One such factor is the impact of the homogeneity of the group. Cohesive groups can agree more easily, especially if there are dominant leaders, but the consequence is to limit creative solutions. Another concern that could be tested is the view that the use of GDSS reduces complexity, not only because of the larger numbers of group members, but also because the only way to find shared criteria is to look for the "lowest common denominator." Cultural effects could also influence the results, and it is our intention to test them by conducting other experiments in other countries.

Another contribution of this work could be to detail the role of the facilitator in supporting a group decision process: Which of the four presented tasks is in fact the most helpful (as judged by the participants and by the resulting decisions)? Knowledge of what is most important in facilitation would not only help human facilitators, it would be relevant to the design of automated facilitation and automated support.

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