End-User Involvement and Team Factors in Business Process Modeling

Peter Rittgen
Vlerick Leuven Gent Management School, Belgium & University of Borås, Sweden
peter.rittgen@vlerick.com

Abstract

We study the impact of end-user involvement and team factors on model quality and consensus. By end-user involvement we mean the degree to which participants of a modeling session are involved in the active creation of models, i.e. the drawing of the diagram. We find that higher end-user involvement, facilitated by tool support, increases model quality. Complementary teams achieve better consensus than matched teams.

1. Introduction

The idea of involving end users beyond knowledge elicitation in the active creation of business process models has been seriously introduced only in the last decade in e.g. [1-6]. Nevertheless, such an approach is not yet widely recognized by the research community let alone standard practice.

It stands to reason that there are many good reasons why this is so but there are equally many reasons to challenge the established way of modeling. Process models play an increasing role in business as business process management systems advance and require process workers to understand the models underlying their process and even to adapt and change them to a certain degree [7]. It is therefore worthwhile to study the effect that end-user involvement has on the quality of the outcome, i.e. the model, and the way in which such participation can be achieved and organized.

The study is of an explorative nature, i.e. the aim is to get a first understanding of several relevant variables and their relations rather than developing a deeper understanding of a few. This leads us to the inclusion of the variables that are introduced in the following paragraphs.

We believe that the best way of achieving end-user involvement is to make it easy or even attractive for participants so that they engage in it at their own discretion. Enforcing it is likely to destroy the collaborative spirit necessary for process modeling.

One way of encouraging end-user involvement is to design the **medium** used in modeling in such a way that it facilitates collaborative creation of models. For that purpose we used a computer-based tool, which makes creating and changing models easier than the conventional medium of brown paper and sticky notes.

As a result, the first hypothesis (H1) is: "The use of a computer-based tool for collaborative modeling leads to a higher degree of end-user involvement."

But does higher involvement in model creation also lead to better models and more consensus? H2a claims: "A higher degree of end-user involvement leads to higher **model quality**." H2b runs: "A higher degree of end-user involvement leads to more **consensus** on the content of the model."

Most measures of model quality consider syntactic, semantic and pragmatic aspects. Consensus, which is sometimes called social quality, actually constitutes a fourth quality dimension. But as it is not included in the established quality measures we treat it separately. Nevertheless, it is equally important [8].

Encouraging end-user involvement is one thing, but organizing it is another. A group of 5-15 people cannot coordinate their model creation efforts efficiently. It needs to be split into smaller units, teams. Team factors are therefore another relevant issue.

When building teams we need to ask: how many members should be on each team and how should teams be composed? For the latter we might consider matched and complementary teams, i.e. the members come from the same or different organizational units.

We expect matched teams to produce better models as they are less likely to entertain conflicting views that can block the constructive development of a model. On the other hand we assume that groups that consist of complementary teams reach higher levels of consensus as conflicts can be resolved earlier and more easily on the team level.

Regarding **team size** we hypothesize (H3a): there is a team size for which model quality is maximal," and (H3b): "there is a team size for which consensus is maximal."

And for **team composition** we assume (H4a): "a matched team produces higher model quality than a complementary team," and (H4b): "a group consisting of complementary teams reaches a higher level of consensus than a group with matched teams."

We investigate the hypotheses with the help of field experiments. For the hypotheses supported by the data we continue with a deeper qualitative study that looks for intermediate variables that explain the results.

The rest of the paper is structured as follows: first we discuss existing research in the field of group modeling. We then elaborate on the issues of end-user involvement and the role that the medium plays. After this we describe our research methodology. Section 5 proceeds with an analysis of the data and section 6 interprets the findings with the help of a qualitative study based on interviews with modeling facilitators.

2. Related Research

Group modeling has been studied intensively in the literature concerning aspects such as the structure of the process itself, its organizational environment and the supporting tools and techniques.

The basic roles and activities in modeling were studied in [9-11] who argue for a separation of knowledge elicitation and model creation. [12] adds that modeling is also about knowledge creation and dissemination in the form of a structured conversation. We basically agree with the latter, more inclusive view on modeling but allow for end-user involvement in the creation of models.

[10] identifies natural language as the primary instrument and calls for face-to-face meetings that are supported by a simple, easy-to-use medium. The computer as a medium has been studied by [13, 14] for general meetings and in [15, 16] for modeling sessions. The conclusion is that tool support has a moderating impact on the group process, which in turn controls the meeting outcome. It is therefore necessary to look at the process itself to identify effects of different media. We do so by including parameters of the process in our study such as team factors.

Beyond the modeling process itself, [17, 18] look at the environment in which this process is embedded. They look at situational factors with the aim of creating better support for software engineering or collaborative modeling in enterprise, respectively. Some issues of these papers are also considered here such as the composition of the team (see below).

In general terms the rich work on brainstorming methods is also relevant for us. Brainstorming is useful for structuring an unstructured problem (see e.g. [19], [20]) but it can also be used to structure existing process knowledge in the face of different views on the process, i.e. different versions of knowledge. We organize modeling sessions as a brainstorming process where participants can contribute their ideas freely in the form of utterances or diagrams (model proposals).

Success factors of process modeling have been studied thoroughly in [21]. This work was on the level of the modeling project whereas we concentrate on a particular modeling session.

End-user involvement, in particular, was studied in [22] under the heading of participatory development. The authors investigate larger groups that work on a rough top-level model with few activities. We consider more focused smaller groups elaborating very detailed flow models. [22] also differentiates between matched and complementary groups but combines both forms in what they call a modeling conference. Our approach studies their mutually exclusive impact.

3. End-user involvement in the creation of business process models

Many researchers describe process modeling as consisting of two activities: elicitation of business process knowledge and creation of a business process model. The terms that are used differ but the concepts agree (see e.g. [9-11]). The division is mainly rooted in the assumption that the actual construction of the model, i.e. the drawing, requires expert knowledge about modeling and the modeling language and the capability of abstraction, and it is generally assumed that domain experts possess neither and cannot acquire them in the frame of a modeling project.

This assumption is problematic in many ways. Let us first consider the aspect of abstraction. While it is true that modeling in general is an abstraction process, the level of abstraction strongly depends on the kind of model to be developed. System dynamics models, for example, require a high degree of abstraction [23], business process models a lower one. Although both describe the behavior of an organization, the former subsumes a lot of behavior under a single variable thereby abstracting from many concrete details, while the latter describes processes on a type level, i.e. their instances are already concrete process executions (cases). Hence business process models are only one abstraction step away from the concrete level.

In addition, preliminary modeling knowledge is not necessarily required either. On the one hand it is possible to design the modeling procedure in such a way that even novices are guided towards a model, even in the relatively abstract area of system dynamics modeling [24]. On the other hand the required subset of a modeling language for business processes is small enough to be learned on the fly even by complete novices, e.g. with the help of a short modeling game [25].

But this does not mean that expert knowledge about modeling is not required. The proposals made by the domain experts need to be consolidated and merged into the final model. In this step the modeling expert, usually the facilitator of the session plays a vital role.

But in the first steps of model creation the effect of the facilitator can be detrimental: elicitation can thwart the enthusiasm of the participants and can stifle their creativity leading to a less active involvement and to less commitment to the result. Participants who have not created the model do often not develop a feeling of ownership. A facilitator can also introduce substantial bias if his role is to dominant.

So user-created model proposals can be beneficial and lead to richer models. But how can we reach a higher involvement? We did not force participants one way or the other. Instead we offered them to contribute their knowledge either in the form of natural language statements, much like in conventional modeling, or in the form of models or model fragments.

We provided the groups with either brown paper and sticky notes, or a computerized tool. We assume that the use of the computer tool encourages a more active participation in model creation and hence a larger number of model contributions as compared to natural language contributions.

4. Research Methodology

As the purpose of this study is to explore relevant factors of end-user involvement in modeling we have included 6 variables, 3 independent, 2 dependent and 1 intermediate. To investigate their relations we set up a number of field experiments as described in 4.4. The independent variables are elaborated in 4.1 and the dependent variables in 4.2. Intermediate variables are discussed in 4.3.

4.1. Independent Variables

The intention of this paper is to study the impact of team factors and end-user involvement, controlled by medium on the outcome of modeling. For this purpose we had to take a closer look at the way in which a group of roughly 5 - 15 people can be divided into smaller units, i.e. teams.

An obvious parameter is the size of the team. We explicitly allowed for the special case of individuals (single-person teams) to see whether modeling work can be better done alone or in real teams. We studied teams of up to three people as the groups in our explorative study had only 5 to 9 members making larger teams unfeasible. In short, we varied the team size in the experiments from 1 to 3. An in-depth study needs to consider larger team sizes including the whole group.

Another controllable factor that is often considered relevant (see e.g. [22]) is that of team composition, i.e. should the members of a team have the same or different backgrounds. There are a number of reasons speaking in favor of each option so it is worth studying their respective impact. We have therefore considered both matched teams where the members come from the same organizational unit, and complementary teams where members come from different organizational units. Please note that only teams of 2 or 3 can be complementary.

As our focus is on studying end-user involvement we also considered another factor: the medium that was used to develop the models. We used two media: the traditional brown paper and a computer-based tool. This was done to study if tool support facilitates end-user involvement, i.e. would encourage people to take a more active role in model creation. Tool support in modeling has been investigated abundantly in literature (e.g. in [15, 16, 26-31]) but often in combination with the methodology that the tool supports. This approach makes it difficult to judge the impact that the tool as such would have on the modeling outcome. A "clean" experiment needs to separate these issues which we have done in the current study.

Knowledge of process modeling or BPMN was not considered as a factor as none of the participants had any prior knowledge of BPMN or prior involvement in creating process models.

4.2. Dependent Variables

The major dependent variable is that of proposal quality, which is defined as model quality, or more precisely perceived quality of the proposal created by each team.

For measuring the quality of the model we rely on a measure that was introduced in [32]. The instrument has undergone and passed content validation, reliability testing and construct validation. It uses four indicators which are assessed on a 7-point Likert scale. They are explained in the following paragraphs.

Quality of models is measured as Perceived Quality of the End Products and is defined as the "… affective attitude towards the outcome (including intermediary and final models) of a modeling process." It comprises the dimensions product quality, understandability, modifiability and maintainability, and satisfaction. Table 1 shows the indicators and their definitions.

Table 1. Dimensions of Perceived Quality of the End Products [32]

Quality Dimension	*Definition*
Product Quality	Product quality refers to the accuracy of the model in depicting all the identified aspects, adequate representation of the domain concepts in the products, abstractedness, clarity and correctness.
Understandability	Understandability of the products refers to the degree to which the modeler comprehends the language concepts represented in the products, e.g., its syntax, semantics, etc., the relationship between the different concepts which are depicted by the products, and the ease with which the modeler can explain the concepts in the products even to those who never participated in the modeling process.
Modifiability and Maintainability	Modifiability and maintainability of the products refer to ease of changing the products to accommodate new changes and the degree to which the products can be kept up-to-date, and how easily they can be reused in the re-engineering and re-structuring of the enterprise processes.
Satisfaction	Product satisfaction of the modeler refers to a positive feeling about the product's quality. This could include satisfaction with respect to the product's correctness, completeness, accuracy, consistency, clarity, understandability and/or its complexity.

But many studies of model quality take a broader look at the quality issue and also look at other quality dimensions. Two dimensions that are often mentioned are the consensus or agreement of the group with the model, and the use or usefulness of the model [22].

In particular consensus is important (and partially determines usefulness) as agreement of all participants with the model is paramount for the success of ensuing change projects where the commitment of stakeholders is crucial, many of whom have usually also taken part in the modeling sessions.

We have therefore decided to include consensus as a dependent variable in our study. We define consensus as the degree to which the team views agree with each other. A view is embodied by the proposal that the team has created. Consensus therefore boils down to the agreement between models. A suitable measure for the degree of agreement or similarity between models was advanced by [33].

We use the measure of linguistic similarity which involves identification of homonyms and synonyms in the phrases that are used to label e.g. activities of a process. The former refers to words having the same appearance (the same letters) but different meanings, and the latter to words with different appearances but the same or similar meaning. This is necessary because people often phrase activities in different ways even if they intend to convey the same idea.

The similarities between model elements was aggregated to the model level as described in [33] using a linguistic similarity weight of 1. For the case of more than two teams the measure also needed to aggregate the bilateral model similarities to the group level. This was done with the help of an equally weighted sum of the bilateral values which corresponds to an arithmetic mean.

4.3. Intermediate Variables

The relation between dependent and independent variables is certainly mediated by other variables but we included only one of them in the quantitative part of the study as it was of obvious interest: the degree of end-user involvement in active model creation The other intermediate variables were studied in the qualitative part of the study (see below).

End-user involvement, or involvement for short, is defined as the active participation in model creation as indicated by the amount of direct contributions to the model in the form of model fragments or complete models as opposed to indirect verbal contributions. The number of verbal and model contributions was counted as described in the next sub-section.

The number of model contributions was divided by the total number of contributions to yield the degree of involvement from 0 (no involvement in creation, only comments) to 1 (full involvement, only models). This value was calculated for each team.

4.4. Experimental Set-up

We have set up field experiments that explore a number of controlled variables as shown above. The modeling language was the same in all experiments, a simplified version of the BPMN (Business Process Modeling Notation) with activities, decisions, sequence flows, parallel flows and swim lanes.

The sessions using brown paper as a medium proceeded as follows. Each team was gathered around a brown paper attached to a wall and apart from other teams. Each participant had sticky notes and a pen available. Team members could freely decide how to contribute: they could write their ideas on the sticky notes, attach a note to the brown paper, or draw on the paper; they could also choose to communicate their ideas verbally.

The former counted as a model contribution, the latter as verbal contribution. A scribe was present close to each team who recorded the number of contributions made in each category.

The tool-supported sessions went as follows. Each team was gathered around a computer that provided access to a modeling tool. Again participants could choose in which way they wanted to contribute.

Tool interactions such as adding, editing, or deleting a node, or connecting nodes were counted as model contributions. They were recorded by the tool. Verbal contributions were counted by the scribe in the same way as in the brown-paper sessions.

In both cases we administered a questionnaire to each participant immediately after the sessions to evaluate the quality of the developed proposals.

We conducted 17 field experiments . The following list shows the organizations that took part and the number of experiments conducted at each:

- IC: a large insurance company (5)
- PA: a large public (city) administration (4)
- GH: a medium-sized general hospital (4)
- PH: a large psychiatric hospital (4)

In 8 experiments we used brown paper, in 9 the computer tool. Group sizes varied from 5 to 9. We had 3 sessions with each of the 3 team sizes with each medium except for the 3-person brown-paper sessions where we conducted only 2. The groups had between 2 and 6 teams leading to a total of 64 teams that were studied. The unit of investigation was the team.

Participants were domain experts without formal training in modeling. Most of them had been present in conventional chauffeured modeling sessions before but have never created models themselves. The modeled processes varied in size from 29 to 45 activities and were of medium complexity.

5. Data Analysis

In a first step of analysis we inspected the boxplots of the dependent variables on the other factors, i.e. the indicators PQ1 to PQ4 of proposal quality and consensus. As an example PQ1 and consensus on team size are shown in Figure1 and Figure 2, respectively.

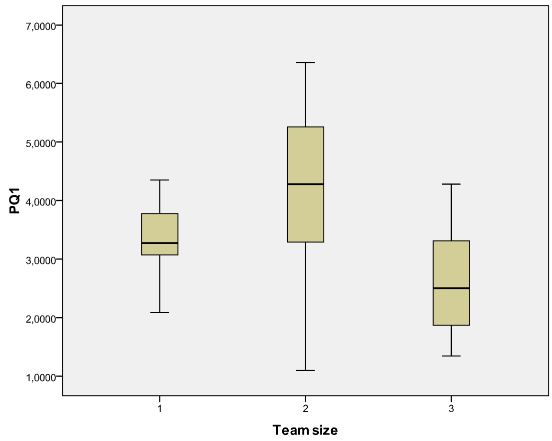

Figure 1. Boxplot of PQ1

The plots show that the dependent variables are clustered by team size. We therefore need to treat the data as three different samples and analyze it as such. It also means that team size is only technically a numerical variable. Small increases in team size lead to large, discontinuous increases in proposal quality and consensus, i.e. team size exhibits the behavior of a categorical variable and needs to be treated as such. We hence have the categories of individuals, pairs and 3-person teams.

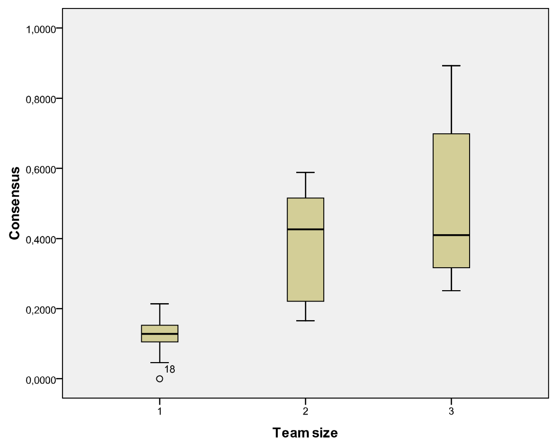

Figure 2. Boxplot of consensus

A normal distribution of the population could not be assumed and the sample size is too small to estimate the population distribution with acceptable accuracy. As a consequence we decided to use non-parametric analysis methods.

To understand the impact of team size on the dependents we subjected them to a non-parametric, three-sample comparison of means by ranks, the so-called Kruskal-Wallis test. The results are significant on the 1% level in all cases, i.e. the samples come from different populations. In other words: team size has a significant impact on proposal quality and consensus.

The mean values are shown in Table 2. The values show that the optimal team size is 2 for proposal quality and 3 for consensus. This confirms hypotheses H3a and H3b, respectively.

Table 2. Mean values of the dependents by team size

Team size	*Consensus*	*PQ1*	*PQ2*	*PQ3*	*PQ4*
1	0.12	3.3	2.9	3.5	2.8
2	0.39	**4.1**	**4.4**	**4.6**	**4.6**
3	**0.51**	2.6	3.0	3.2	2.6

A similar test was carried out for team composition, which is also a categorical variable. The results were significant for consensus but not for proposal quality. The latter means that hypothesis H4a is not supported by the data.

The mean values of consensus are 0.17 in the case of matched teams and 0.57 for complementary teams. Hence, complementary teams perform significantly better in building group consensus, which supports hypothesis H4b.

Finally we looked at the relation between medium, involvement and the dependent variables. We used again a non-parametric test to be independent of the distribution of the variables. We performed a rank-based correlation analysis according to Spearman.

Except consensus all variables exhibited significant correlations on the 5% level. The analysis was limited to a team size of more than 1 as meaningful correlations cannot be computed for individuals. The respective ρ values are shown if Figure 3 which summarizes the relations found in the quantitative part of the study.

The medium did indeed influence participants in their decision to get involved in model creation. In the tool-supported sessions participants made significantly more model contributions than in the brown paper sessions. As a consequence hypothesis H1 is supported by the data.

Higher end-user involvement in creating proposals also had a significant and strong effect on their quality with ρ values ranging from 0.788 to 0.888. This means that hypothesis H2a is also confirmed. No support for H2b could be found, though. This calls for further investigation.

The following section interprets these results and also includes the variables that mediate the relations.

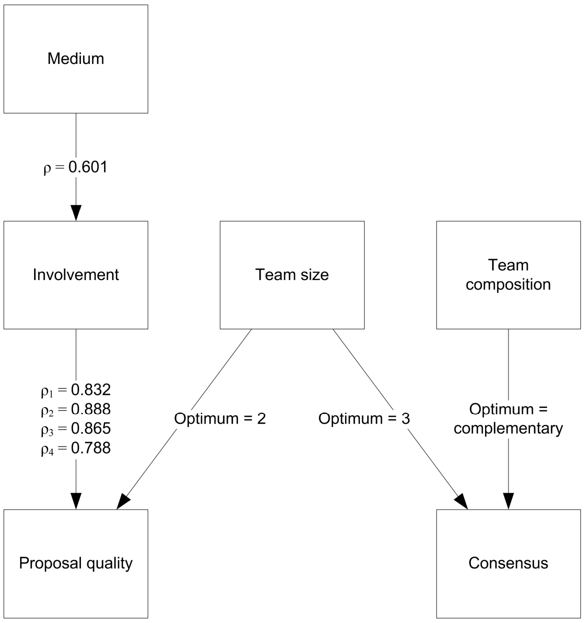

Figure 3. Team factor model

6. Interpretation of Results and Intermediate Variables

So far we just found that there are indeed relations between the studied variables but we know little about their nature. We have therefore decided to take a closer look at the relations, in particular concerning possible mediating variables.

To do this in a systematic way we searched the literature for determinants of model quality and consensus. Based on this we developed four lists of candidates for the factors of the dependents, the intermediate variable and the medium as described in the following.

Model quality: there is substantial literature on metrics for business processes. A survey paper [34] identifies complexity, understandability, quality, entropy, density, cohesion, and coupling as the measures that were most frequently addressed in literature.

Consensus: there is less research on the factors of consensus in modeling. Few studies address consensus in modeling at all, e.g. [35, 36]. [37] summarizes the most relevant factors: separation of idea generation and evaluation, enforced participation (no free-loading), absence of conformance pressure, and speedy convergence through e.g. ranking or voting. Learning from others as a means to understand each other and reduce conflicts is also relevant here.

Medium: Anonymity, simultaneity, group memory, and group size are often named as factors of tool support for meetings (e.g. in [38]).

Involvement: Cognitive theories offer explanations of why people get involved in a task. Focus Theory [39], for example, mentions goal commitment as a driver for individual effort.

Structured interviews were performed with the facilitators in the field experiments immediately after the modeling sessions. They were asked five questions, one for each of the relations in the model shown in Fig. 3. Each question ran: "What factor explains best, according to your experience, the impact of X on Y?"

Respondents were first asked to come up with a factor on their own, i.e. without any help from the interviewer or the factors on the lists. This was done to ensure that respondents were not led to an answer and possible new factors could be identified.

Only if respondents were unable to find an explanation we offered the respective list for Y (and, if applicable, also for X) and asked them to pick the most appropriate factor from it. They could also use the list as an inspiration only and still come up with a new suggestion.

We only included the factors that were mentioned by at least half of the respondents. Table 3 shows the results. Early conflict resolution and adaptability are new factors that were not represented on the lists.

Table 3. Intermediate factors

Predictor	*Involvement*	*Proposal quality*	*Consensus*
Medium	Adaptability		
Involvement		Understandability, richness, accuracy	
Team size		Individual effort, goal commitment, free-loading	Learning from others
Team composition			Early conflict resolution

6.1. Medium and Involvement

The majority of facilitators mentioned adaptability as the main factor explaining the greater involvement of participants in active model creation in the tool-supported sessions. By adaptability they mean the fact that changes to an intermediate version of the model were easier to effect with the help of the tool. Changes on the brown paper were harder to do and required substantially more effort. As a consequence the teams using the computer-based tool were involved in model creation to 87% as opposed to the 72% of the brown-paper teams, an increase by 15%. In the larger teams of three this effect is even more pronounced with an in increase from 38% with brown paper to 68% with the tool.

6.2. Involvement and Proposal Quality

Understandability, richness and accuracy were mentioned as primary factors here. Higher involvement led to more understandable models and eventually to a proposal of higher quality.

More involvement also facilitates richer proposals, i.e. proposals that contain a higher percentage of each team member's knowledge about the respective process. The medium has an indirect effect here via increased involvement but also a direct effect: A rich proposal requires the use of the modeling language as a complex state of affairs is hard to articulate verbally. Proponents who rely on natural language therefore tend to make simpler suggestions that need to be aggregated by the team. Both the process of repeated natural-language statements and their compilation are error-prone and lead to lower proposal quality. The average values of the indicators of proposal quality PQ1 to PQ4 ranged from 2.9 to 3.3 in the brown-paper case, and from 3.7 to 4.1 in the case of tool support, an average increase by 25%.

More involvement also improved the proposal's accuracy, i.e. the degree to which it conforms to reality according to the perceptions of the team members. This is also due to the fact that verbal contributions are easily misinterpreted or misrepresented.

6.3. Team Size and Proposal Quality

According to the expertise of the facilitators the major reasons for the impact of team size on proposal quality were individual effort, goal commitment and free-loading (or the absence thereof). Goal commitment was seen as the main driver for individual effort, and a lack thereof as a reason for free-loading.

Free-loading is the fact that less motivated people will shirk effort and leave the work to other team members.

In a larger group it is easier to free-load than in a smaller so this behavior was seen by the facilitators of the three-person teams primarily. Goal commitment decreases as the team size increases. This is because members identify themselves more readily with a smaller team and its goals as group cohesion is greater there.

Taken together this means that the best proposals should come from a team of one person but knowledge added by other teams members compensates this so that the optimal team size is actually two, providing a good balance of team cohesion and diversity.

6.4. Team Size and Consensus

Learning from others was seen as the major reason why larger teams perform better in terms of achieving consensus. If a group is divided into many small teams we arrive at a large number of different proposals and hence different views. With respect to group consensus small teams therefore perform badly. Team members learn little from each other and the conflict is just postponed to a later stage of modeling.

On the other hand, if we divide a group into few larger teams we generate fewer but more consolidated proposals. In a larger team people learn more from each other and can therefore resolve many conflicts internally so that they do not surface to the group level.

6.5. Team Composition and Consensus

The impact of team composition on consensus can be explained by the concept of early conflict resolution. The members of complementary teams come from different organizational units and are therefore likely to entertain different views on the process whereas in matched teams members are more likely to agree with each other. In a complementary team issues can therefore be discussed and potentially resolved much earlier, i.e. before the proposals are discussed in the whole group.

A conflict can be resolved more easily in a small team than in the larger group. The small team has a greater cohesion and is more focused on the problem as personal issues play a lesser role. Conflicts also tend to be harder to resolve in later stages of the modeling process when positions are more likely to have hardened.

7. Conclusion

Our aim was to get preliminary knowledge about the drivers for model quality and consensus from the perspective of involvement and team organization. We explored a modeling procedure where end users have the opportunity to directly represent their knowledge in a business process model.

We assumed that such a procedure would empower participants and give them a stronger influence on the model and more room for creativity. As a result they are likely to develop a feeling of ownership and better agreement with the model. This has in turn a positive effect on their commitment to the modeling project and facilitates an ensuing change effort.

To confirm the assumptions we did a number of field experiments where we studied the impact of team factors and the utilized medium on model quality and consensus both in a quantitative way, to identify and validate relations, and in a qualitative way to explain them more profoundly.

The results suggest to make use of a computerized modeling tool and complementary teams of two for process modeling tasks of medium complexity that involve between 5 and 15 people.

The results of this study are certainly indicative but they need to be confirmed in in-depth studies focusing on each of the identified relations. In addition, we only concentrated on factors that are located on the team level and target proposals. There is a need to extend the factor model to cover also variables that operate on the individual and group levels. This is subject to further research.

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