Anyone can use models: Potentials, requirements and support for non-expert model interaction

Alexander Nolte, Michael Prilla
Information and Technology Management
Institute for Applied Work Science
University of Bochum
Universitätsstraße 150, 44780 Bochum, Germany
Tel.: +49-234-32-27721
Fax: +49-234-32- 14207
E-mail: {nolte|prilla}@iaw.rub.de
Web page: www.imtm-iaw.rub.de

Abstract

Models play an important role in modern organizations. They are used to coordinate the interplay of stakeholders, inform the design of software systems and are even used for controlling purposes. While these models affect multiple people within an organization their creation and usage is limited to a few experts. This is due to the common belief that non-expert modelers are not capable of performing modeling tasks or working with models without the help of experts. With this paper we argue that people are capable of interacting with models when they are given the right means to do so. We shed light onto the potential benefits of non-expert model interaction by conducting multiple case studies and describe suitable tool support for non-expert modelers.

1. Introduction

In modeling research and practice, it has been recognized that model creation and manipulation benefits from stakeholder involvement – such integration is considered to be essential when processes are documented, improved or newly designed (e.g. Herrmann, 2009; Schmidt, 1997; Suchman, 1995). Based on the insight that "users are experts and (…) designers (…) are technical consultants" (Schuler & Namioka, 1993), there are many approaches of participatory modeling, actively involving stakeholders. However, most approaches only allow users to inform the design of processes and leave the modeling work to experts. As a consequence, the interaction of users with models is limited to co-located situations guided or facilitated by experts. While this guidance is helpful in many ways, it is also time-consuming to schedule and conduct such workshops, as both experts and stakeholders need to be coordinated and need to cooperate in workshops. If stakeholders could actively engage in modeling tasks, this would allow them to prepare models for these workshops or adapting them to their needs. Limiting contributions by stakeholders to modeling workshops potentially reduces commitment to the process and also negatively

affects the accuracy[1] of the models (Prilla & Nolte, 2012) due to two reasons: First, it slows down adaptations to models that capture changes happening in the real world. Second, it adds an extra loop of interpretation into modeling, as experts ask stakeholders and add their understanding of what they say about a process to a model. This also results in models being perceived as artifacts of experts with no implications on actual work (Prilla, 2010).

There is also a problem in model usage: Although models are tools for the documentation, analysis, design and improvement of processes, they are almost exclusively used by a small group of modeling experts and managers. Other members of the organization oftentimes are neither aware of models nor able to access them (see Prilla, 2010; Wand & Weber, 2002 for further descriptions of this problem). Furthermore modeling tools are difficult to use for non-expert modelers, which also limits active stakeholder involvement. So despite more user interaction with models being desirable, there are not many insights into whether and how non-modeling experts can use or manipulate models in a self-regulated, that is, non-guided way. However, our own experiences with e.g. participatory modeling workshops (see section 3.1) showed us that people are willing and capable of engaging more actively into model interaction than commonly supported. In this paper, we describe a stream of research motivated by these experiences. It investigates the question to what extent non-modeling experts can interact with process models and how this interaction can be supported by tools and interfaces (see section 2.4 for a detailed description of research questions).

In the remainder of this paper, we will analyze existing literature according to non-expert interaction with models (section 2), leading to four research questions (section 2.4). Based upon our previous experiences with participatory modeling (section 3) we strive to answer these questions in three studies we conducted (section 4). Results of these studies lead to insights on non-expert model interaction (section 5.1) and the description of prototypical modeling tools and interfaces we are currently developing to support this interaction (section 5.2).

2. Related Work and description of domain

At this stage, it is necessary to be explicit about the **central terms** used in this paper. First, by **non-expert interaction with models** we refer to actions of creating, referring to, using and manipulating models by a group of users who are neither experienced nor explicitly trained to work with process models. The term **'non-expert'** thus only applies to the modeling skills of this group, not to their expertise in other domains. Second, we differentiate between **using a model** for certain purposes and **creating or manipulating** it. By **using a model**, we mean activities such as referring to it during communication or sharing knowledge with the help of a model. In contrast, activities of **creating or manipulating models** always lead to changes and will be subsumed by the term **'modeling'** throughout this paper. Thus, despite this differentiation, this paper covers both of these activities and subsumes them by the term "**interaction with models"**.

[1] By accuracy we refer to the ability of a model to describe or comply to real world processes (e.g. Ssebuggwawo, Hoppenbrouwers, & Proper, 2010).

This section will provide an overview of existing approaches of such interaction, covering stakeholder involvement into modeling (2.1), approaches of non-experts directly interacting with models (2.2) and non-experts collaborating on models (2.3) and showing challenges and gaps in these approaches and derive research questions (2.4).

2.1. Participatory and collaborative modeling: Stages of stakeholder involvement

Participatory and collaborative modeling approaches have been a focus of interest in various domains due to early criticism pointing out that without stakeholder participation models do not represent real processes (e.g. Schmidt, 1997; Suchman, 1995). As a result, there are multiple approaches of participatory model usage and design in fields such as process management (Dennis, Hayes, & Daniels Jr, 1999; Herrmann, 2009), system dynamics (e.g. Rouwette, Vennix, & Thijssen, 2000) and others (e.g. Dean, D.; Orwig, R.; Lee, J.; Vogel, 1994). All of these approaches aim at creating a shared understanding of a problem domain among participants and are usually based on workshops in which process stakeholders and other people such as domain experts are involved in modeling.

The way of user involvement – i.e. the participation concepts (Schuler & Namioka, 1993) – in these workshops differs, ranging from feedback to models to active modeling by non-experts. In approaches often used in the business process modeling (BPM) domain, user involvement is reduced to feedback given to the session facilitator on a model created by modeling experts (based on the information provided by process stakeholders) beforehand (van der Aalst, ter Hofstede, & Weske, 2003). As this is perceived to be no adequate solution of stakeholder involvement, stronger forms of participation have been developed that are based upon structured conversation (Hoppenbrouwers, Proper, & Weide, 2005), which usually are guided by a facilitator (e.g. Herrmann, 2009).

It is a common finding that the outcome of these workshops strongly depends on the skills and expertise of facilitators (e.g. Ackermann, 1996; den Hengst, 2005). In this context, there is a need to distinguish between **process facilitators**, who support the course of the overall workshop and e.g. guarantee that all participants are involved, and **modeling expert facilitators**, who are responsible for integrating participants' contributions into a process models and may also operate the modeling tool (c.f. Richardson & Andersen, 1995 for a more sophisticated distinction). In practice, these roles might be taken by the same person.

Other approaches allow parallel work by participants on a model synchronously (Rittgen, 2009), which has proven to be faster, as changes to the model can happen in parallel (Dean, D.; Orwig, R.; Lee, J.; Vogel, 1994). Despite positive results being reported, there is still an argument whether non-experts can properly use models without further support - opponents of this claim e.g. argue that process complexity and the need to use a modeling language hinder non-experts to do so (Mendling, Reijers, & Cardoso, 2007).

2.2. Approaches for non-expert model interaction

Allowing for direct interaction of stakeholders with models – i.e. to actively manipulate models – still remains a major concern in research. This is largely based upon the fact that

modeling tools are usually not available to everyone and even if they are, it is hard to use them, as they are built to suit the needs of experts rather than novice users. However, direct interaction with models makes collaborative modeling more flexible and less dependent on modeling experts. Thus, it is suspect to research from a variety of directions.

Tangible process modeling allows for people to use physical shapes resembling elements of modeling notations for modeling (Grosskopf, Edelman, & Weske, 2010). Remaining problems are the necessity to transfer models into an electronic form and the necessity for expert guidance keeping track of the syntactical correctness of the resulting model.

Another approach are systems that allow to specify models in **wiki syntax** (Dengler, Lamparter, Hefke, & Abecker, 2009) as well as systems that use wikis to find models and comment on them (Rospocher, Ghidini, Pammer, Serafini, & Lindstaedt, 2009). Again the syntactical correctness is a major issue as well as the requirement to translate the comments into elements according to the modeling notation.

Dialogue games are another way to involve stakeholders more directly into modeling (Hoppenbrouwers & van Stokkum, 2011). This idea stems from the notion that modeling workshops can be perceived as structured conversations and that these conversations can in parts be guided automatically.

2.3. Collaborative usage of models: Insights

Next to their creation, the usage of models has also been discussed in the past. It is oftentimes shown that models have the potential to support people in making perspectives explicit, understanding the work of others, jointly planning work and communicating about it (e.g. Herrmann, 2009; Suchman, 1995). In science and practice related to HCI and CSCW, this is also mirrored by the wealth of methods applying models for the design of cooperation support (e.g. Beyer & Holtzblatt, 1998; Conklin, 2005; Herrmann, 2009).

The major advantage associated with using models is that they provide a basis for communication about their content. In particular, models have been observed to mediate communication between stakeholders from different backgrounds – e.g. designers and users – and to support the negotiation of perspectives among them (Herrmann & Hoffmann, 2005). In this sense, models serve as boundary objects (Star, 1989) between different parties. In addition, models are reported to support cooperation and coordination tasks if used by a group working together (Schmidt, Tellioglu, & Wagner, 2009). Other advantages include knowledge transfer in organizations (Amaravadi & Lee, 2005) and the support for navigating in process structures and well as in contents of information systems (Schmidt, 1997).

Although these insights generally show that there is potential in using models, none of these contributions described details how people actually use them. Therefore, there is need to shed light on the actual usage of models in practice. Moreover, most of these studies describe situations in which models are only used by non-experts together with experienced modelers. How and whether non-experts can use models, i.e. make sense of them and communicate about them on their own, remains unclear.

2.4. Challenges and gaps in non-expert model interaction

The literature review points out the potential of non-expert involvement into process documentation and design. However, it also shows that this potential is not fully tapped, which is caused by a lack of understanding how to integrate people in these tasks and how to support them. In what follows, we elaborate on research questions resulting from this.

The dependency on a facilitator is a recurring topic in literature. Although there are indications that non-experts can interact with models, it remains unclear to which extent this is **enabled (only) by a (model expert) facilitator** and which **kind of tasks** non-experts may carry out on their own. However, the need for a facilitator can be a bottleneck for users to actively engage in process modeling (there is not always a facilitator available). This leads to the following research question:

(RQ 1) Can tools support non-experts to conduct typical modeling tasks without a model expert facilitator and for which tasks is support by model expert facilitators needed?

Literature shows that **people experience difficulties in using modeling tools and languages** if they have not been trained for this. Thus, despite approaches showing ways around these problems (c.f. section 2.2), it still remains unclear (and is even doubted) whether non-experts can express processes **on their own**. This also holds true for the usage of models, which is hindered by the same factors and leads to two important questions:

(RQ 2) To which extent are non-experts capable to explicate processes, that is, to which extent can they model conceptually?
(RQ 3) How can non-experts use models for cooperation?

Enabling non-experts to interact with models on their own also depends on suitable **technical support**. From literature (c.f. section 2.2), we know that modeling tools are built for experts and provide a burden for non-experts. Therefore, we also need to find ways to enable people to use models and to contribute to them on a tool and interaction level:

(RQ 4) Which means of interaction are suitable to support model interaction for non-experts and how can tools be designed for this interaction?

It is obvious that none of these questions can be answered in solitude – e.g. the question on potential modeling tasks (**RQ 1**) cannot be isolated from suitable tool support for them (**RQ 4**). In what follows, we demonstrate this by experiences from stakeholder integration in practice (section 3) and by study setups seeking answers for the aforementioned questions (section 4).

3. Non-expert model interaction: Experiences and Open Issues

3.1. Participatory modeling in practice: Applying the Socio-Technical Walkthrough

Throughout the previous years we worked with non-experts interacting with models in several cases and developed a participatory modeling approach named the Socio-Technical Walkthrough (STWT; Herrmann, 2009). It consists of a series of workshops in which process stakeholders cooperatively develop process models with the help of a facilitator. The facilitator walks them through the process by asking questions such as "What has to happen next?" or "Which resources are needed for that?". The statements of participants are immediately integrated into the model, resulting in the model being the center of work and communication. During these workshops there are often situations where different parties start discussing how the process is conducted and how it should be visualized within a model (cf. Schermann, Prilla, Krcmar, & Herrmann, 2008). This shows that participatory modeling enables non-experts to get involved in process documentation and design.

While the STWT works well and produces good results, our experience with it and literature (section 2.1) show a major shortcoming: As such approaches rely on an experienced facilitator and representatives of process stakeholders (c.f. Herrmann, 2009), modeling workshops are hard to organize, which slows down the progress of process documentation and design. Involving stakeholders into modeling outside modeling workshops might increase modeling efficiency, but requires investigating which modeling tasks can be carried out by non-experts on their own, that is, without a model expert facilitator.

3.2. Model interaction by non-modelers in organizations: A study on potentials, need and barriers

In order to understand potentials of non-expert involvement in working with models, one of the authors conducted an interview study with six process modeling experts (cf. Bruno u. a., 2011; Prilla, 2010), who had five or more year of experience working on models with users from their organization. This group of people was chosen, as they have an overview on how models are used and by whom. As this study was designed as an exploratory approach, the number of participants was deliberately kept low. During the interviews, which lasted about 60 minutes, each participant was asked about the usage of models by non-experts, about the availability of models and about barriers and success factors of model usage by non-experts. The interviews were audiotaped and transcribed. The resulting material was coded in three consecutives loops based on Grounded Theory (Strauss & Corbin, 1998). This coding process produced 102 distinct codes, which were converted into 14 use cases and 30 requirements.

The material revealed that non-experts frequently use models to coordinate their actions and to communicate about their processes. Interviewees reported that non-experts are able to understand models and use them as a shared representation of work and that experts regularly talk to non-experts about models in order to assure their correctness. We also found that the continuous presence of experts during model usage leads to non-experts not using models on their own. Additionally, the interviewees reported that they understand their role as a guide and guardian for models, which in turn might discourage non-experts from using models

actively (see also Prilla & Nolte, 2012), and that they are often called by non-experts, which in their opinion shows that non-experts feel uncomfortable with modeling.

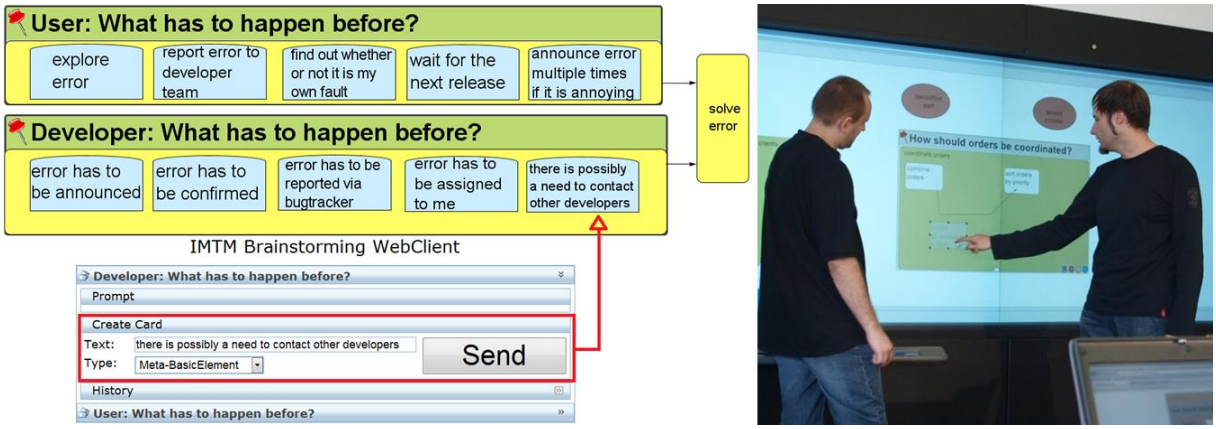
These results show that non-experts can understand and use models, but that experts play a decisive role in this usage, which limits the involvement of non-experts. Thus, we need to find ways to preserve the mediating power of experts while reducing the disadvantages resulting from experts being too present.

4. Towards non-expert support for process model development and usage: case studies on interaction with models

Within this section we will describe three different case studies on non-expert model interaction. We start by describing the tools we used and the environment we conducted all of the studies in (4.1) and continue by providing an overview of how the studies are related (4.2) followed by a description of them (4.3 to 4.5).. All of the studies were videotaped and we had an additional observer taking notes.

4.1. Study support: Tools and environment

Our studies are based on a process modeling tool for the modeling notation SeeMe[2], which was developed in the group the authors work in. Besides other functionality, this tool is equipped with a web-based interface allowing multiple users to add items to a process model by typing text into an input box (see Figure 1, left). Sending text input results in an element inside the modeling tool with the corresponding label. The tool is prepared to being used in a special laboratory, which is equipped with an interactive large screen (Figure 1, right) allowing for touch interaction with models. The laboratory also provides equipment for audio and video recording from different angles.



[2] For more information on the tool and the method visit www.seeme-imtm.de

Figure 1: Contributions to a model via a single text input box in a web-based interface result in an element with the respective label in a modeling tool (left). The resulting model can be used on an interactive touch screen (right).

4.2. Gaining insights into non-expert model interaction: A qualitative approach

Striving to answer the research questions described in section 2.4 we conducted three studies, each aiming at a specific aspect of non-expert model interaction. The first study (section 4.3) examined whether brainstorming is a suitable task for non-experts to contribute to modeling (**RQ 1**). In the next study (section 4.4) focus was on process documentation and the capability of non-expert to engage in this task (**RQ 2**). Analyzing another task from the same study (section 4.5), we investigated which tasks of model interaction non-experts are capable of (**RQ 3**). Within all of the studies we tested whether textual input (sections 4.3 to 4.5) and direct manipulation on an interactive large screen (section 4.4 and 4.5) provide suitable means for non-experts to interact with models (**RQ 4**).

4.3. Integrating phases of brainstorming into group model building

In a study to evaluate this purpose of the tool described above (Figure 1), we conducted three workshops with four to six participants each and a facilitator (c.f. Herrmann, Nolte, & Prilla, 2012). In the workshops, we asked the participants to collaboratively develop a process for the selection of job applicants. For this, they used the tool in different phases of the workshop, answering the question "Which activities are needed for an innovative process of selecting participants?". All participants were knowledgeable about applicant selection processes but most of them were either completely new to modeling or used models only occasionally.

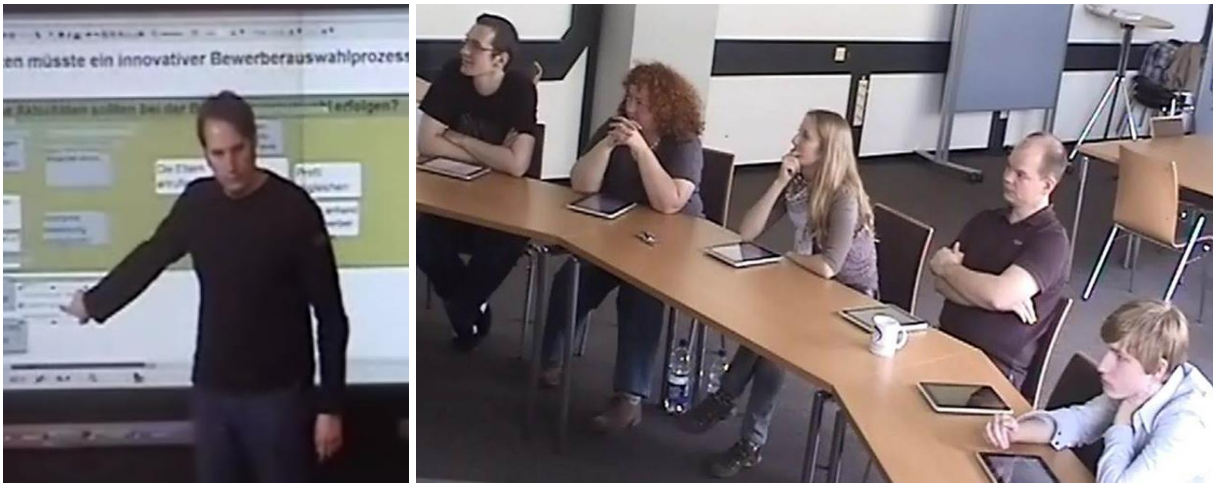


Figure 2: The facilitator sorts contributions on the interactive large screen (left), while the participants are waiting to start contributing with their mobile devices (right).

In an initial phase lasting 5 to 8 minutes, the participants were asked to provide ideas for parts of the process. Afterwards, the facilitator started clustering the contributions according to their sequence in the process, discussing them with all participants. During this phase, the participants were explicitly asked to continue contributing items. In addition to videotaping the workshops, we performed group interviews after each workshop.

The analysis of the resulting video material and notes were done by iterative loops of watching and annotating the videos. This analysis shows that working with the interface was

easy for the participants as they contributed a lot of elements in a short period of time and reported no difficulties using it. This indicates that textual contributions are a suitable way for non-experts to add to process models (**RQ 4**). In the initial brainstorming phase, we found some participants switching between phases of using the tool and phases in which they looked at the model in order to be aware of process elements already contributed. Asked about this, they reported that they aligned their contributions to those of others. Moreover, the participants worked with different velocities: While some contributed the majority of their items in the first half of the brainstorming phase, it took other participants time to think about contributions, which they added later in this phase. These observations show that the participants understood the model and made sense of its elements during the brainstorming and that they work at different speeds, which has to be taken into account when designing support.

During the clustering phase people rarely contributed new elements. We also found participants starting to write not submitting their contribution afterwards. In the interviews, we were told that it had been difficult for them to keep track of the discussion while writing down new ideas in parallel. This indicates that for non-expert model interaction, a clear distinction between phases of contribution and discussion is required.

These observations suggest that given a clear separation from other tasks, brainstorming into process models is a task that can be fulfilled by non-experts without guidance in performing modeling tasks (**RQ 1**) – there was only process facilitation. It also shows that non-experts are able to use models to orient their work on them.

4.4. Process documentation by non-experts through a textual interface

Taking into account the premise of people's difficulties to express themselves in modeling languages (see section 3.2), we thought that our tool could be also be used to *translate* non-experts' utterances into model syntax. We explored this in a second study, using a setting in which two participants were asked to document their respective view of a process they both knew well. For this, we used two different scenarios, in which the participants took different roles of major actors in the process (see Table 1 for an overview).

Table 1: Scenarios used in the study, including roles, participants and pairs 1 to 5 (P1 to P5).

Scenario	Roles included	Participants / Pairs
(1) Bug reporting and solving for software development	User (of the software), Developer	3 Pairs: 1 tool user and 1 developer each *(P1, P3, P4)*
(2) Book ordering in a library	User (of the library), Librarian	2 Pairs: 1 library user and 1 library clerk each *(P2, P5)*

We conducted five workshops (see Table 1), which lasted about 30-45 minutes each. The workshops started with the participants independently adding elements to their own process model. For this, they used the tool described in section 4.1 and typed in the names of process elements to be displayed. During the phase of input, the contributions of one participant were

hidden from the other. After this phase, the participants were asked to use the interactive screen to sort their contributions according to their correct sequence. A process facilitator guided the participants through the course of the study, telling them about general tasks, but he did not intervene with any content related (modeling) tasks.

Table 2: Number of contributions per pair during the collection phase of the study.

Pair	Time (Parts 1 and 2)	Number of contributions	Contributions per minute
P1	6 minutes	11	1,8
	5 minutes	12	2,4
P2	5 minutes	16	3,2
	3 minutes	21	7
P3	2 minutes	12	6
	4 minutes	14	3,5
P4	4 minutes	11	2,8
	4 minutes	10	2,5
P5	8 minutes	17	2,1
	5 minutes	18	3,6
total	46 minutes	146	3,1

The participants contributed an average of 3,1 elements per minute (142 items within 46 minutes). The respective phases of contribution ranged from 2 to 8 minutes with an average of 4,6 minutes per phase and was significantly different among groups with 8 being the longest and 2 being the shortest time (c.f. Table 2). These numbers indicate that the interface was easy to use: Despite limited or no experience in modeling, the participants had no difficulties creating a sufficient amount of elements to sketch their respective process (c.f. Figure 1, left for a sample process).

We also saw that our participants were capable to think in process structures, as they had no difficulties in constructing a sequence out of their contributions (all participants had to move only very few elements around during the second phase of the workshop) and to identify sequence related differences between their respective processes. We conclude from this that – up to certain extent – non-experts are capable of simple modeling tasks such as sequence building (**RQ 2**).

The study also points to limitations of non-expert modeling. We deliberately chose processes of little complexity and the resulting models are far from being sophisticated and usable for people that were not part of their development, remaining on a very abstract level and leaving out detailed descriptions. These limitations might stem from non-experts lacking the required knowledge to visualize processes properly or from the task that made them stay on this level of modeling. These limitations indicate that for more detailed modeling, currently model expert facilitation is still required (**RQ 1**). Further work will need to investigate whether tools may also support more complex modeling.

4.5. Self-regulated model interaction

Within the same setting as described in section 4.4, the participants, were asked to compare their view of the process with the model created by the respective other. In detail, they were supposed to spot and mark differences – both in sequence and in the content of their models – to discuss them and find a resolution. Again, the facilitator only instructed them to perform the tasks. This work was videotaped and we analyzed the material in two consecutive loops of coding based on Grounded Theory (Strauss & Corbin, 1998) in order to detect patterns of interaction with models and aspects of collaborative work on them. The resulting material consists of about 150 codes, 32 comprehensive codes and five categories describing characteristic ways of interaction with the models.

Our analysis revealed a lot of **discursive interaction with the models**. Similar to findings on the influence of pictures on communication (Fleck & Fitzpatrick, 2009), we found that the participants used the models as references in discussions and to guide their communication, e.g. one participants asking the other what she meant by a certain model part. We even observed them telling stories about the model (see Figure 3): „Once I am sure for which case I need a book [first element] and when I know whether to buy it or not [second element], then I send you an email [third element] and (…)“ (P2.2). We also found participants underpinning statements by pointing to model elements and embedding them into communication statements, such as „We also need to take this [pointing to element] into account“ (P3.2).

Figure 3: P2.1 pointing to model elements to depict what she is talking about and moving physically in front of these elements, starting in the first half and going to the end of the model (sequence captured within 6 seconds).

Alongside communicative and deictic references to models, we observed patterns of **coordination in work with models**. Most prominently, the participants physically moved towards the model element they were talking about (see Figure 3). When changes were to be made, they coordinated this verbally before or afterwards, e.g. “What do you think? Correct?” (P1.2). In addition, the participants followed patterns such as handovers e.g. by explicitly telling the respective other that it is her turn and role reversal, e.g. by one taking the role of the active modeler while the other restricted herself to inform her (Figure 3).

Without being explicitly asked to do so, the participants showed **cooperation based on the models**. They negotiated process content and we observed them trying to develop a common understanding of the process as in P3.1’s question “and the difference in your model is (…)?” answered by P3.2 with “Yes, exactly”. Furthermore we also observed participants learning something new about the process, e. g. “I have to admit that I have not thought about what the library does to be prepared for my orders” (P5.1).

Besides these, we also found **limitations of non-expert model interaction**. Some participants added to the model "what has to happen there according to my opinion" (P3.1), rather than documenting the process as it is. Likewise, we observed discussion outcomes in favor of higher-ranked persons (c.f. Nolte & Prilla, 2011). In rare situations, discussions even ended up in conflicts with partners angrily disagreeing with each other. These are typical situations in which tools cannot fully support users, but process facilitation is required.

Our observations suggest that non-experts can use models in various ways (**RQ 3**): The study participants oriented their communication towards the models, coordinated their interaction e.g. using the touch interface for manipulation of models (**RQ 4**), and cooperated on them. At the same time, e.g. due to problems in interaction between participants, a facilitator is sometimes still needed to solve conflicts (**RQ 1**). We need to investigate whether tools can – and should – provide support for these tasks without a human facilitator present. Notwithstanding this question, the study indicates that there are tasks for which non-experts can use models in a self-regulated manner.

5. Discussion: Insights, open issues and tool support for non-expert collaborative model interaction

The studies described in section 4 shed light on potentials and limitations of non-expert interaction with models. They show tasks that can be done by non-experts on their own, that organizational and technical support are necessary for this and that there are barriers and open issues. Thus, we conclude that lacking support for non-expert model interaction is not (only) due to lacking capabilities for modeling but also to missing insights into these capabilities.

5.1. Results and limitations: Insights and open issues in non-expert model interaction

The studies provide answers to the research questions posed in section 2.4. Considering the question which tasks of interaction with models non-experts can perform without expert guidance (**RQ 1**), we found that they can **add items to process steps** in process design (section 4.3), that they can **compose sequences** for processes they know (section 4.4) and use models to support cooperation (section 4.4). This suggests that non-experts can prepare simple models for workshops (sequences of tasks) or negotiate open issues. The complexity of this interaction has to be kept low: If tasks interfere with each other (c.f. discussion and contribution to models, section 4.3) or if hierarchies are involved (section 4.5), model interaction becomes difficult for non-experts. Likewise, the models created in the studies are not as sophisticated as models stemming from expert facilitated modeling workshops. Thus, we suppose that additional guidance or tool support is needed for more complex tasks.

Considering the capability of non-experts to explicate processes (**RQ 2**), we can conclude that people are capable of thinking in sequences and explicating them. This can be seen by their orientation towards sequence related clusters (section 4.3), by the low amount of changes they made to sequences they provided (section 4.4) and by behavior such as explaining process along sequences (section 4.5). We also need to take into account that non-expert modelers may work at different speeds (section 4.3).

We also found non-experts being able to use models in different ways (**RQ 3**): They performed tasks that emerged from interaction with models, because of spatial proximity to elements, negotiation, knowledge transfer and storytelling based on models (section 4.5). This shows that people can understand models and that they can communicate and cooperate on them. In the context of our studies, we consider digital tangible interaction with models on an interactive screen as one key to using models for cooperative tasks, as it diminished the distance between users and the model. This suggests that people can use models for cooperation given suitable means of interaction.

Considering tool support for non-experts (**RQ 4**), the numbers presented in Table 2 indicate that the text interface for modeling (section 4.3 and 4.4) was easy to use and relieved the participants from the burden of translating their thoughts into a modeling notation or using a complex modeling tool. This suggests that **reduced means of interaction** such as the text interface or the touch interaction (section 4.5) support non-experts in contributing to models and using them in cooperation, as they reduce the complexity of modeling. We conclude that **natural interaction** such as **translating** text automatically to model syntax (section 4.4) and gestural interaction (section 4.5) diminishes the burden to use modeling languages. However, we need to take into account that reduced interaction also results in lower accuracy. So for complex modeling tasks additional guidance is needed. Combining support for non-experts with these important constraints for modeling is the challenge for the design of future tool support.

5.2. Support for a new generation of modelers: Current prototypes

Based on the insights described above, we developed prototypes providing novel ways of supporting non-experts in their interaction with models.

First, as non-experts still need guidance for more complex modeling tasks, we designed an interface providing **automatic guidance** for the documentation of processes. Like the tool used in our studies, this tool (see Figure 4) uses textual input for interaction and guides the user through the modeling process by asking predefined questions. Answers to these questions are **translated** into elements according to the modeling notation as described above. This is similar to approaches such as IDEF0 (Dennis, Hayes, & Daniels Jr, 1994), but in contrast to these is intended to work without any upfront training

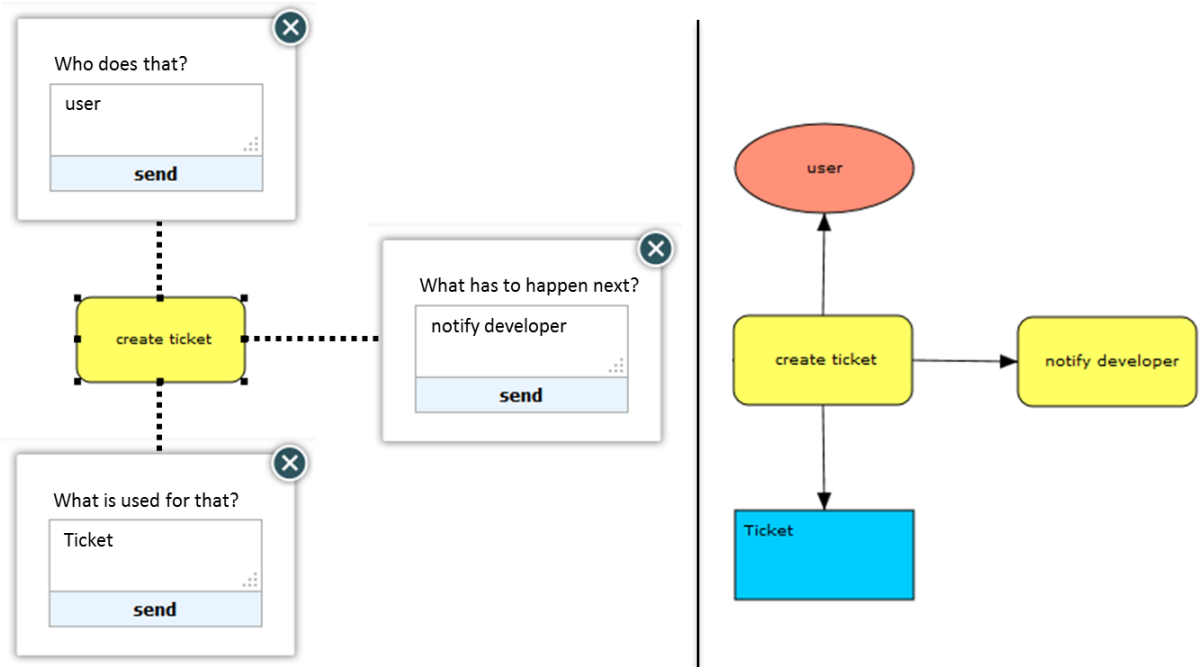


Figure 4: Answers to predefined questions (left) result in elements according to the modeling notation with the respective text as their label (right).

While the tool shown in Figure 4 supports users in creating richer models, we found that additional support is needed to create more complex processes than simple sequences. Therefore, our second prototype complementing this supports **meta modeling**: Starting with a single, generic element (c.f. *create ticket* in Figure 5 bottom-left), a user may use tags to describe the process she wants to model. The tool then searches existing models containing the same or similar tags and proposes these models to the user (Figure 5 right). These proposals include a small preview window to evaluate a model at a first glance and a full-scale preview to select parts of it. If the user has found a suitable model, she may select parts of it or add the whole model into the previously created generic element. This allows people to document complex situations on their own without any further guidance.

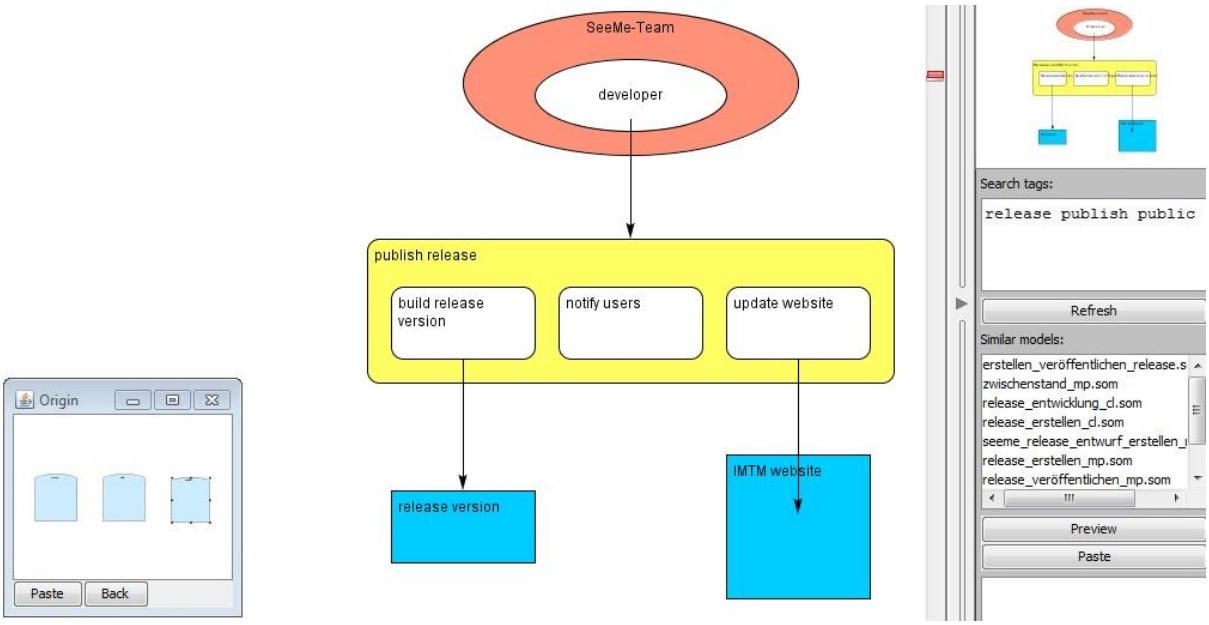


Figure 5: The original meta-element that the modeler created (bottom-left) can be filled with the elements displayed in the middle. The listing on the right shows a list of the models that the tool has found and also displays a preview.

To tackle problems such as different speeds and parallel interaction in co-located modeling workshops, we will explore a tool that allows users to choose to which part of the process they want to contribute to (Figure 6, bottom-left, see Prilla & Nolte, 2010, for a more sophisticated description). The tool also allows for some people to continue contributing while others start discussing contributions and altering sequences (Figure 6, top-right).

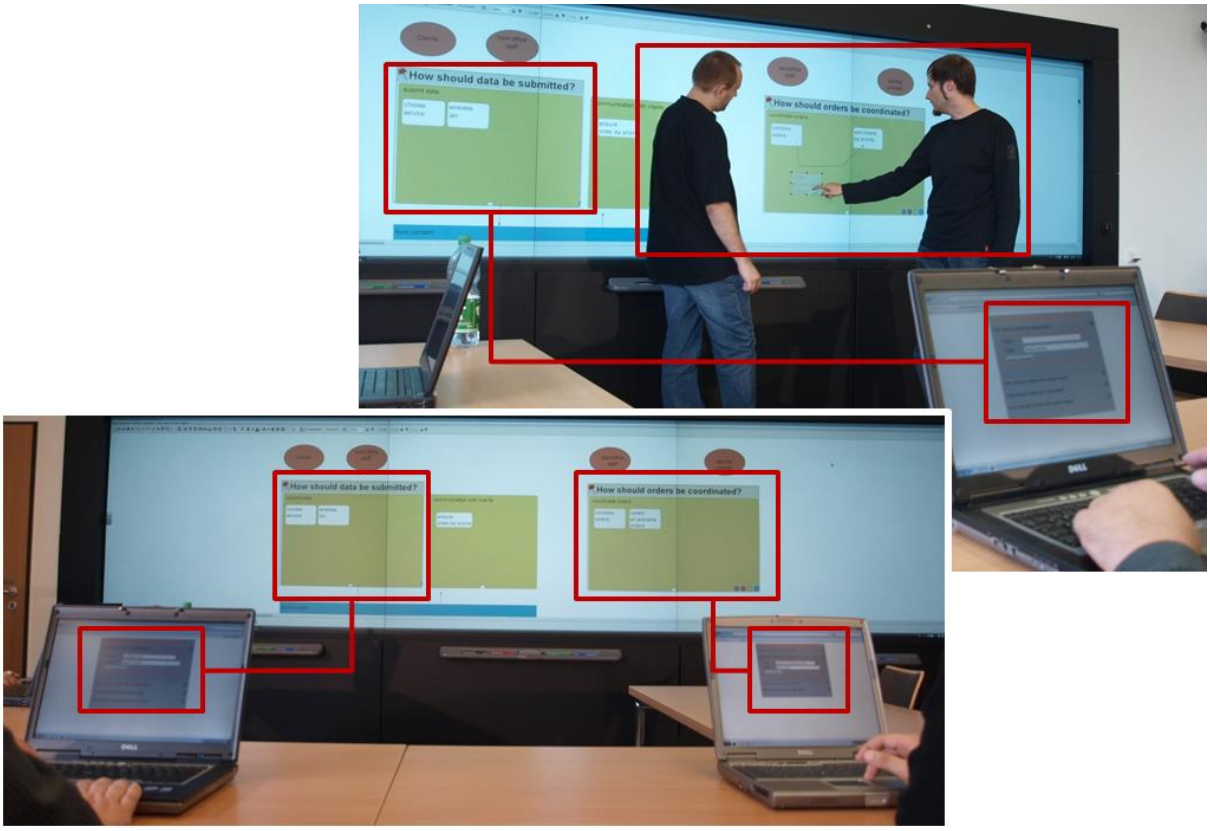


Figure 6: Two participants working on different parts of the same model in parallel (bottom-left). Afterwards one participant continues contributing to one of these parts while others start working on their contributions by building sequences (top-right).

While at the time of writing this paper these tools are still prototypes we expect them to change the way models can be created cooperatively, tapping the potentials of self-regulated modeling and diminishing its limitations. Studies on their application in practice will need to reveal whether these expectations will come true.

6. Conclusion and further work

The work described in this paper is devoted to investigating the capabilities of non-experts in interacting with models in order to identify proper support. The results described suggest that there is a lot of potential in this work, but also that there is still work to do until non-experts can engage in meaningful modeling tasks on their own.

We showed that non-experts can perform simple modeling tasks and that they can use models for cooperation. The key to this is **adequate tool support**, which can be characterized as

providing natural (i.e. well-known) and reduced (i.e. isolated and less complex) interaction with models such as using textual input to models. For tasks requiring more complex interaction or more complex modeling functionality, we found that non-experts are still facing difficulties and need better support.

One should note that despite our focus on supporting tasks that can be done without a model expert facilitator, our work does not intend to get rid of human facilitation in modeling. Our results do not show whether this is possible at all, but we showed that there are tasks of model interaction, which are not dependent on (continuous) model expert facilitation. This makes existing approaches of participatory and collaborative modeling more flexible and widens the circle of model users in organizations. This, in turn, supports expert facilitators, as during workshops they can focus on complex tasks and leave simple tasks such as the preparation of a process sequence to workshop participants.

In future work, we plan to pursue the work described here, working towards an integrated processes of guided and self-directed model interaction. We consider applying the prototypes described in section 5.2 as an important step towards these goals and plan to complement this step with studies on further tasks of model interaction.

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