Chapter 12
Collaborative Business Process Modeling in Multi-surface Environments

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Abstract Analyzing and redesigning business processes is a complex task which requires the collaboration of multiple actors such as process stakeholders, domain experts and others. Current collaborative modeling approaches mainly focus on modeling workshops where participants verbally contribute their perspective on a process along with ideas on how to improve it. These workshops are supported by modeling experts who facilitate the workshop and translate participants' verbal contributions into a process model. Being limited to verbal contributions however might negatively affect the motivation of participants to actively contribute. Interactive technology such as smartphones, tablets, digital tabletops and interactive walls can provide opportunities for participants to directly interact with process models. Multi surface environments where different interactive technologies (e.g. display walls, tabletops, tablets, and mobiles) are combined also allow for orchestrating different modes of collaboration. In this chapter we describe an approach that combines different styles of collaboration using various interactive surfaces in a multi surface environment. Testing this approach in three different

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settings we found indications that interactive technology not only improves involvement by participants but also speeds up workshops and improves the quality of collaboration outcomes. The studies also revealed means for improving the proposed approach.

12.1 Introduction

Business process management (BPM) can be considered a relevant practice for most organizations. BPM is among the main drivers for organizational development and innovation and organizations commit ongoing and substantial investments in BPM projects which range from 500,000 to 50,000,000 USD per organization according to Harmon [1]. The basis for most BPM projects are graphical representations of processes in process models. They are used to document processes and to analyze and improve them. Process models are also used as training material or as a basis for software development [2]. Creating process models is a complex task because real world phenomena have to be depicted which might include a mesh of activities that are conducted by a number of different actors (c.f. *Goods receipt officer* and *Booking Clerk* in Fig. 12.1 left). In order to depict such processes in a model it is also necessary to translate real life phenomena into elements of a modeling notation and integrate them into a process model which adds to the overall complexity. Modeling notations consist of a set of graphical symbols such as rectangles and ellipses, which represent process parts such as actions, and actors and they also provide rules for how symbols may be combined. Figure 12.1 shows an example for a model of a goods receipt process where the actors are depicted as lanes (booking clerk and goods receipt offices) and tasks as yellow boxes.

Knowledge about a process is usually distributed between different groups of stakeholders and domain experts with each of them potentially having a different perspective on a process. Most stakeholders though are not capable of analyzing and visualizing processes on their own because they lack methodological education and practice both with respect to gathering information about a process and translating that information into constructs of a modeling notation. The latter might

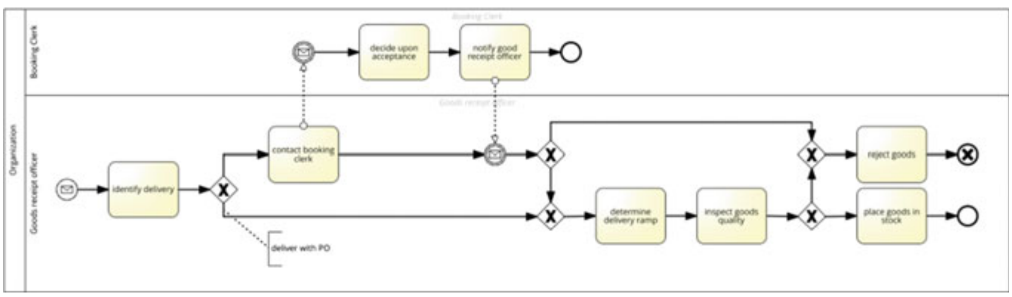

Fig. 12.1 Part of a model for goods receipt process based on the business process model and notation (BPMN [24])

sound surprising at first since modeling languages such as the Business Process Model and Notation (BPMN) were specifically created to be easy to use and understand [3]. Studies on the understandability of process models however show that stakeholders generally are not capable of depicting complex phenomena using a modeling notation without being trained to do so [4, 5]. In order to analyze and visualize processes they consequently require the support of modeling experts who are knowledgeable about a modeling notation and about approaches to analyze processes and improve them. Modeling experts usually come from outside of an organization and are thus hardly knowledgeable about one particular process that has to be visualized in a process model. In order to acquire the information required for process modeling, modeling experts rely on a number of different approaches such as document analysis, interviews, observations, workshops and more. During the course of this chapter we will focus on collaborative approaches since misunderstandings and diverging perspectives about processes become more obvious in a mode of discursive collaboration. This not only leads to a better understanding of a process but also improves the quality of business process models [6–9].

Collaboration in this context usually happens in facilitated workshops where stakeholders and domain experts are supported by modeling experts to analyze and visualize processes in process models and subsequently derive means for improving these processes [6, 9, 10]. During those workshops modeling experts serve as facilitators who organize workshops, guide the communication during the course of these workshops and translate verbal contributions of participants into elements of a modeling notation (c.f. Fig. 12.1). It is common that more than one modeling expert supports a workshop since it is not possible for a single person to guide the communication, translate contributions into a modeling notation and operate a process modeling tool to integrate contributions into a process model [9, 11].

Current workshop approaches are often criticized as being inefficient [12, 13] since they suffer from a number of inherent limitations. Some limitations stem from that all communication has to be channeled through the facilitator since she has to process all contributions before they are integrated into a process model. This effect is commonly referred to as the facilitator bottleneck [13]. Furthermore, limiting participants to verbal contributions potentially leads to a missing sense of participation and a missing sense of ownership of a process model. This in turn might lead to a lack of motivation to participate during a workshop, a reduced buy-in for process changes and a subsequent missing motivation to apply process changes into everyday work practice [13]. Finally, most approaches in collaborative modeling solely focus on participants working together in a single group, while there are indications that collaboration in varying constellations during the course of a workshop cannot only positively influence collaboration outcomes but also the perception of collaboration itself [14–16].

The wide spread of touch enabled devices such as smartphones and tablets alongside the emergence of multi surface environments [17, 18] provides an opportunity to overcome some of the aforementioned limitations. Multiple studies have already shown the feasibility of using interactive technology in the context of process modeling [19–21]. They indicate that the possibility for multiple users to collaborate on large touch devices such as large interactive touch display walls and digital tabletops positively affects collaboration and collaboration outcomes [19, 21]. Alongside these findings there are also indications that personal mobile devices can positively influence collaboration outcomes [15, 22]. Mobile devices can also serve as a means of tying phases of collaboration together by allowing for a seamless switch between phases of collaborating in large groups and phases of working in smaller subgroups [16, 23]. Taking these approaches as a background we propose a concept which aims at **creating a space where interactive surfaces such as smartphones, tablets, digital tabletops and large interactive touch display walls support and facilitate the orchestration of collaboration on business process models**.

The remainder of the chapter is structured as follows. In the following section we describe current BPM approaches highlighting the necessity for collaboration especially during process analysis and re-design using process models (Sect. 12.2.1). Afterwards we provide an overview of how interactive technology can be used in multi surface environments (Sect. 12.2.2). Based upon these reviews we describe a setting for collaborative process modeling in a multi surface environment (Sect. 12.3). Based upon this setting we propose three distinct collaboration styles as well as means of fluid transitions between them before showing three case studies during which different collaboration styles were tested (Sect. 12.4). In what follows we discuss results from these case studies (Sect. 12.5) before providing an outlook on future research (Sect. 12.6).

12.2 Background

During the course of this section we describe BPM approaches and highlight potentials for interactive technology in the context of collaborative modeling. These potentials then serve as a basis for the collaboration styles that are described in Sect. 12.3.

12.2.1 BPM and Collaborative Modeling—Potentials and Pitfalls

BPM is a body of principles, methods and tools to design, analyze, execute and monitor business processes, with the ultimate goal of improving these processes [2]. BPM affects efficiency, effectiveness, and thus competitiveness, of organizations. Companies invest millions of dollars into BPM initiatives and in return obtain the increase in productivity, improvement in quality of service, reduction of operating costs, and faster process cycle times.

BPM initiatives often deal with business process models. A business process model is a specification of business activities, or tasks, and constraints between them that an organization commits to follow to reach its objectives. There are several commonly accepted notations for capturing business process models including BPMN [24], EPC [25], and UML activity diagrams [26]. All of these modeling notations are similar in the sense that they all provide a set of graphical symbols that can be combined with textual labels in order to visualize processes. These symbols cover all aspects of a business process such as actions, actors, resources, decisions and relations [2]. Modeling notations also provide a set of rules of how elements can be combined. Process models are usually created within computer systems that are specifically tailored to support one or multiple process modeling notations (e.g. Signavio[1]).

In order to succeed in volatile business environments, organizations perpetually design new business process models and improve existing ones by re-evaluating customer needs and analyzing real world executions of the deployed business processes. Designing a new or improving an existing business process model is a complex task that often requires different expertise from several domains. Note that business processes usually involve multiple departments within an organization or capture business procedures that involve multiple organizations. Hence, a business process modeling exercise often takes place in a highly collaborative setting such as the ones described in the introduction. The success of collaborative business process modeling largely depends on the quality of methodologies and tools used to guide and support the collaboration as well as the skill of the facilitator [12, 27, 28]. Through a joint creation of BPMN models, EPC models, or activity diagrams, stakeholders acquire shared understanding of operational procedures within their organizations.

The state of the art of collaborative modeling focuses on studies of facilitated workshops [6, 9, 12, 29]. There are a number of different approaches to facilitate such workshops including structured walkthroughs [6], scripts [30], or flexible collaboration patterns [31]. In facilitated workshops, a dedicated person acting in a special role of a facilitator translates individual verbal contributions of process stakeholders into a modeling notation. Workshops are usually divided into phases. During a first phase, aspects of a current as-is process are collected. These parts are then consolidated and aligned to each other in order to form a representation of the current as-is process. Afterwards this visualization is used as a basis to identify means for improving the process and discuss how the process could be altered (e.g. make it more efficient). Once a consensus is reached, the discussed changes are integrated into the process model to form a visualization of a future to-be process [2, 10, 32].

Collaboration support should subsequently fit each of the aforementioned phases. Most of the approaches focus on a single style of collaboration as described above. This leads to the perception that participants perceive workshops as

[1]http://www.signavio.com.

ineffective. They stay mostly limited in their ability to actively interact with and directly contribute to the model that is being created. This may subsequently lead to a missing sense of participation [33] and a lack in the sense of ownership over the artifact developed in the course of the workshop by its participants, which in turn may lead to a lack of motivation to participate during the course of a workshop and may later translate into a weak "buy-in" and reuse of the model. Moreover, facilitated workshops may suppress spontaneous creativity of its participants as all the changes to the model are incremental and are administered centrally by the facilitator [14].

Luebbe and Weske [34] study the use of tangible media in business process modelling workshops. For that they used glass cut outs of BPMN elements which could be labeled using felt pens. They conclude that the use of tangibles by all workshop participants allows them to actively contribute to the model creation process, which leads to more effective process elicitation. In particular, participants of the experiments reported that they get better insights into process modeling. However, this approach solely focusses on single participants eliciting process models while our focus is on collaborative modeling. The approached proposed by Luebbe and Weske also focusses on a single constellation while we aim at supporting multiple collaboration styles in order to address the different phases of collaborative modeling.

12.2.2 Multi Surface Environments in Collaborative Modeling

A major component of engagement on the part of process modeling with stakeholders is the need for tools that provide an appropriate visual to aid in both the cognition of stakeholders using the tool, but also their ability to then communicate their concepts, and to relate information presented to their colleagues in an intuitive and cognitively low overhead manner.

It is all well and good to e.g. provide a large interactive touch display wall which allows users to interact with process models. The possibility to interact with materials on a touch display will not improve engagement of user by itself since they require appropriate visualizations, and support. This is a current topic of research still requiring refinement [35]. There is also research suggesting a need for more flexibility in collaborative modeling workshops thus supporting different means of collaboration [14, 16]. We cover these following issues briefly and focus on how they contribute to the collaboration tasks at hand.

Representations—People understand their domain using particular visual forms that are amenable to the cognitive and work models of the stakeholders (c.f. different visualizations of the same process on the large screen in the top of Fig. 12.2), shown by evidence from cognitive fit experimentation [36]. Not only is this effect evident from a theoretical analysis of representational approaches [37] but also from

Fig. 12.2 Multi surface environment: variation of different visualizations on different devices such as large interactive touch display walls (*top*), digital tabletops (*bottom left*) and personal mobile devices (*bottom right*) in collaborative modeling

user habituation, which has formed trained constructs that are easily understood using the visual language of that stakeholder's domain [38].

Relationships—Just placing items of visuals besides each other in temporal sequences is not necessarily useful to the process of collaboration; explicit relationships between the domain information must be added to aid in communicating these concepts between the stakeholders [35]. In previous work, we have analyzed multi-domain visualization in a 3D sense for manufacturing, juxtaposing process information with other engineering data, providing relationship disambiguation as part of the design [39]. We propose that touchscreen process modeling frameworks will allow other data in the form managed by diverse stakeholders in management (e.g. Bill Of Materials (BOM), accounts, IT operations) and physical operational representations (e.g. 3D workplace representations [40]) to be displayed, and related to each other, side by side, in order to assist in discussion and collaboration.

Scale—The use of large display walls provides room to show both relationships and context of information presented to stakeholders, allowing people to gather around the representations for analysis. As well as collaborating on one representation, large interactive touch display walls allow people to move easily between representations, without the cognitive overhead of multiple displays on machines causing loss of context via excessive eye movements [41]. As well, the size of the representations has an immersion effect by filling the visual field and engaging the viewer's senses more strongly [42, 43].

Flexibility—there are situations in collaborative modeling where a single large display visualization is not sufficient since participants have different interests with respect to different parts of a process [44]. It is thus necessary to provide a setting, which supports different constellations with respect to collaboration. These constellations have to cover working in solitude as well as working in smaller subgroups and working in a single group together [14, 16]. In these settings smaller touch enabled devices such as tablets or smartphones appear to be more reasonable (c.f. Fig. 12.2 bottom right).

Styles of collaboration—several further dimensions influence the collaboration between the participants. Aspects of time matter: the usage of the tools within a multi surface environment depends on the length of a meeting. The shorter the meeting the less effort can be invested to switch between various tools or to organize several cycles of collecting ideas and refining ideas. It might be the case that collaboration within the whole group is put into the foreground of individual work, which can even include work results, which have been helped outside of the meeting room. The choice of how participants collaborate depends on the decision whether a workshop will focus on divergence or convergence of ideas and contributions [14]. In the latter case it is important that all participants are aware [45] of which decisions have been taken and how they are represented in a model. Furthermore, the size of the collaborating group decisively influences its decision of how to use the media of a multi surface environment and of how to switch between them. Another important difference refers to the question whether the participants' individual work and contributions always take place in a public space and are immediately visible to others, or whether they are prepared in a private space and an explicit decision is needed to make them available to others [22]. Figure 12.2 shows an example of how different views on different devices can be combined in a multi surface environment. Similar settings have explored oil and gas exploration [17], emergency management [46], geospatial interaction [47], software visualization [48], and software development team meetings [49].

Such issues bring up a rich set of research questions with regards to both the social and technical aspects, that need to be addressed in order to fully utilize the novel affordances of such constellations in process modeling. Example questions can be:

1. What is the optimal combination of representations to use in such a process modeling scenario?
2. What is the optimal relationship representation that can be developed to ease interactions between team members of different domains?
3. What is the optimal combination of collaboration styles for each phase of the modeling process?

12.3 Collaborative Modeling in a Multi Surface Environment

Based on the previously described review we will propose a concept for collaborative modeling in a multi surface environment. The concept includes three styles of collaboration based on an environment that combines different interactive surfaces such as large interactive touch display walls, digital tabletops and personal mobile devices. For each of these styles we will describe how they work in the proposed setting and for which specific aspects of collaborative modeling they may be useful. We will describe how these styles can be intertwined and how the described setting as well as the different collaboration styles affects facilitators and participants.

12.3.1 Environment

Supporting collaborative process modeling we propose a setting where different interactive devices are placed within a single room thus creating large multi surface environment that allows multiple users to simultaneously interact with different representations of a process model using different devices or interactive surfaces [50–52]. These devices include large interactive touch display walls as well as digital tabletops and personal mobile devices such as tablets and smartphones. Participants can interact with process models using touch gestures which were derived from previous research into the use of touch gestures for process modeling [20]. The underlying design rationale was to create interfaces that are easy to use and fast to learn. A comprehensive overview of gestures for business process modeling used can be found in Nolte et al. [53]. Furthermore, we made sure that the appearance of the interface as well as the ways on interacting with the displayed materials is identical for all devices.

In order to allow simultaneous interaction with models using different devices we created an application where the model itself resides on a server, which handles all changes to a process model. The software provides means of concurrency control to ensure that conflicting actions by different participants at the same time cannot result in corrupted models [54].

12.3.2 Styles of Collaboration

In what follows we will describe three distinct styles of collaboration for process modeling in a multi surface environment. These styles are based on limitations of current approaches and serve as an example for how collaborative modeling can benefit from interactive technology in multi surface environments. In addition, we will describe an approach to support switching between different collaboration styles.

Collaboration Style 1: Parallel contributing by individual work
In this collaboration style, participants contribute to a process model in parallel using a personal mobile device (e.g. smart phone or tablet). Contributions are integrated into a process model which can be—but need not—immediately displayed on a large interactive touch display wall and are thus visible for all participants during the whole course of a workshop. Succeeding, contributions can be collaboratively altered or combined using the large interactive touch display wall (c.f. Fig. 12.3). It is not possible to alter or delete elements using personal mobile devices since we perceived it as valuable to be able to collaboratively discuss all contributions by all participants.

Collaboration style 1 is especially suitable for the early phases of process documentation where parts of a current as-is process are collected. During this phase it is common practice to document a process from its start to its end before identifying means of altering or improving the process. This activity can be very time consuming in a workshop setting where participants can only contribute verbally since all contributions have to be picked up by the facilitator, translated into elements of a modeling notation and integrated into the process model. During this phase of divergence, only a few participants are active at the same time since and not every participant is knowledgeable about or interested in all aspects of a process.

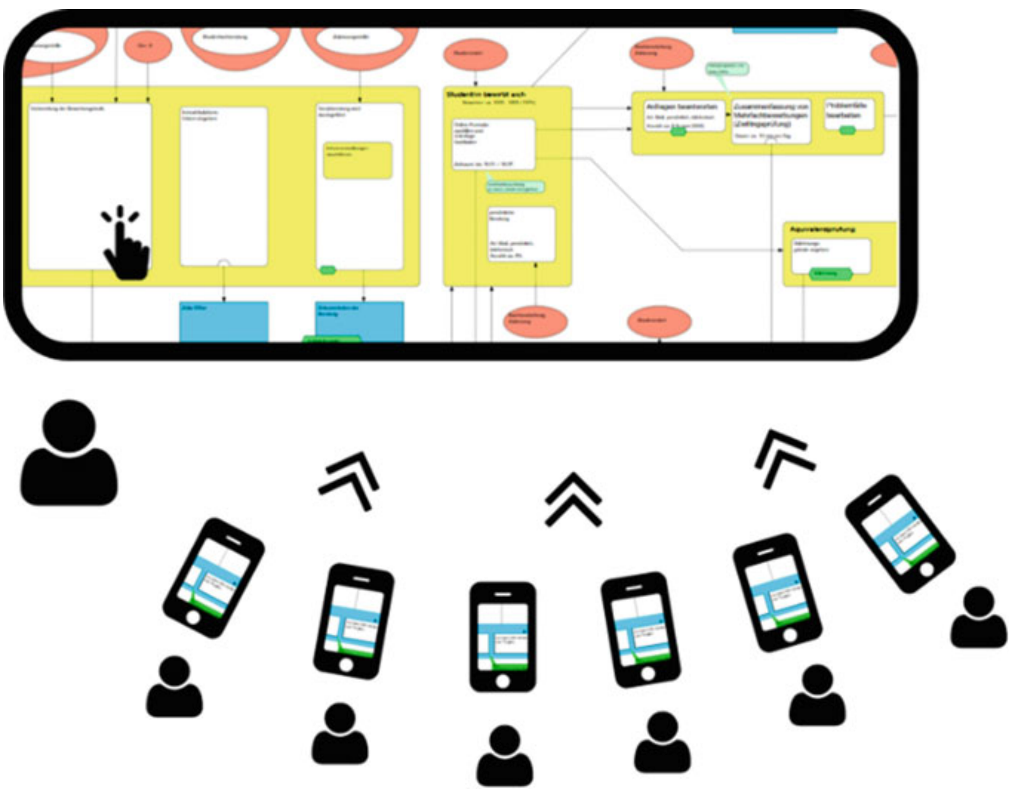

Fig. 12.3 Participants contributing to a process models using personal mobile devices

Allowing participants to contribute in parallel using personal mobile devices can increase the efficiency of collecting relevant process parts significantly [15].

Collaboration style 1 is not only suitable for phases where a process is documented. It can also be feasible to allow for parallel contributions during phases where ideas have to be developed on how to improve a process. In a classical workshop setting participants would have to wait for other participants to state their respective ideas which can for example lead to production blocking [55]. Production blocking describes an effect that occurs when someone cannot express an idea directly but has to wait for her turn to speak. This can result in that person forgetting the respective idea or altering it in a way that it fits the contributions of others. Parallel contributions via mobile devices can potentially overcome this effect. Contributions via mobile devices can also reduce the fear of being evaluated by others (evaluation apprehension [56]) since ideas do not have to be expressed verbally but can instead be contributed anonymously through a personal mobile device.

Collaboration Style 2: Collaboration in smaller sub-groups

In this collaboration style, the whole group of participants is split into smaller sub-groups which collaborate using larger interactive devices such as digital tabletops or large interactive touch display walls (c.f. Fig. 12.4). This style is similar to

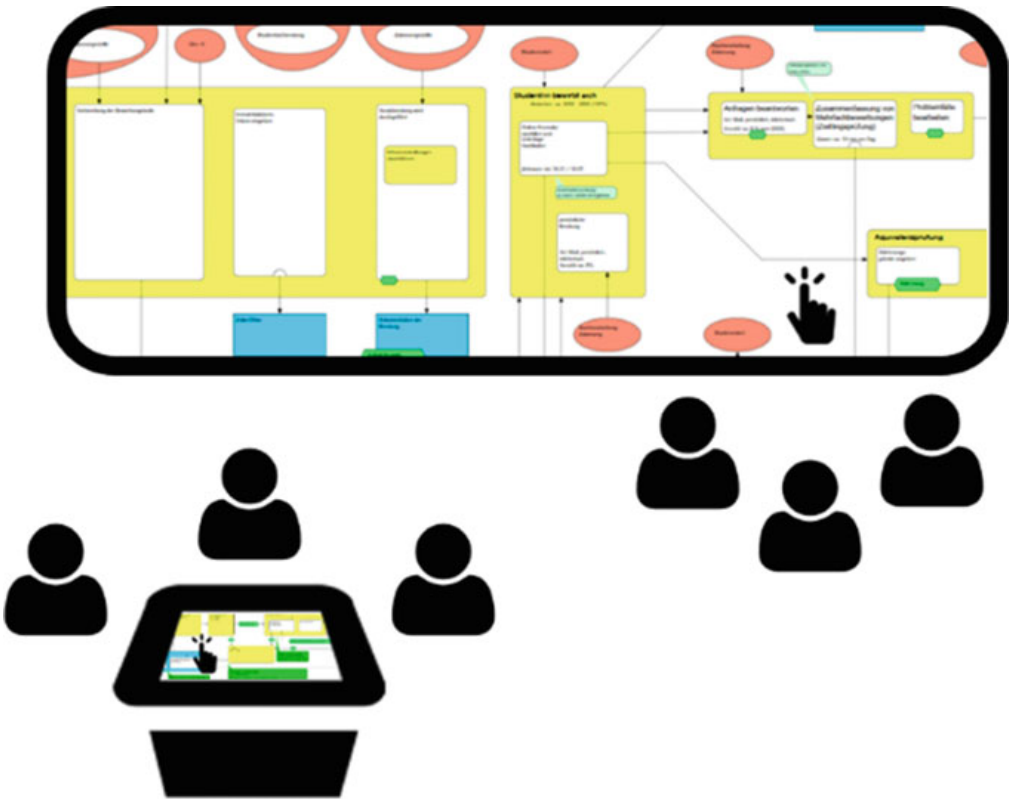

Fig. 12.4 Participants collaborating in smaller sub-groups using digital tabletops (*bottom left*) or a large interactive touch display wall (*top*)

the previous one since all participants can contribute in parallel but instead of using one input device each, they now share an input device within a small group of e.g. two to four participants. In this style it is also possible to alter existing model elements, combine them or delete them using the respective touch interfaces.

This collaboration style supports situations in which it is possible to build on a prepared process model, or in situations where process parts have already been collected. This style allows for sub-groups of participants to discuss aspects of a process they are interested in. Discussions can focus on identifying means of supporting certain process parts by IT or on discussing details about how collaboration within the process could be improved. The main reason for dividing one large group into smaller subgroups in a workshop setting is that—as discussed earlier—not all participants are knowledgeable about or interested in the same aspects of a process. This style allows participants to form interest groups that can focus on certain aspects of a process in parallel thus potentially increasing workshop efficiency. A facilitator in this context can serve as an initiator for those phases and she can serve as a modeling expert if certain participants struggle in expressing their ideas using a modeling notation.

Collaboration Style 3: Collaboration in a group together

This collaboration style is similar to a typical workshop setting where the participants collaborate in the group together. This style is suitable for phases of convergence where e.g. previously gathered process aspects are combined into one large process or where different ideas on how to alter a process are discussed. However, while in other settings, the participants are limited to verbal contributions, this setting allows them to modify the process model at any point in time using a touch interface on a large interactive touch display wall (c.f. Fig. 12.5). Similar to the previously described collaboration style, all participants can contribute in parallel but this time they all have to share the same device which is a large interactive touch display wall instead of a digital tabletop or tablet in order to support larger group sizes. Here it is again possible for all participants to alter the process model in various ways using the touch interface on the display wall. This includes adding elements, altering them, putting them into relation with each other and deleting them.

Similar to the previous collaboration style, this style aims at phases during the course of a workshop where parts of a process model already exist that have to be consolidated. This style supports exchanging perspectives of all participants, discussing different views and ultimately reaching a common understanding about the process as a whole. The latter is especially important since the previously described collaboration styles did not allow for participants to reach a common understanding throughout the whole group since they were either working in solitude (c.f. collaboration style 1) or in smaller sub-groups (c.f. collaboration style 2). Reaching a common understanding about a process is a prerequisite for reaching a consensus [57] about future process changes or at least an acceptance for compromises. Allowing participants to alter the process model at any point in time using large interactive surfaces potentially improves the motivation of participants to actively

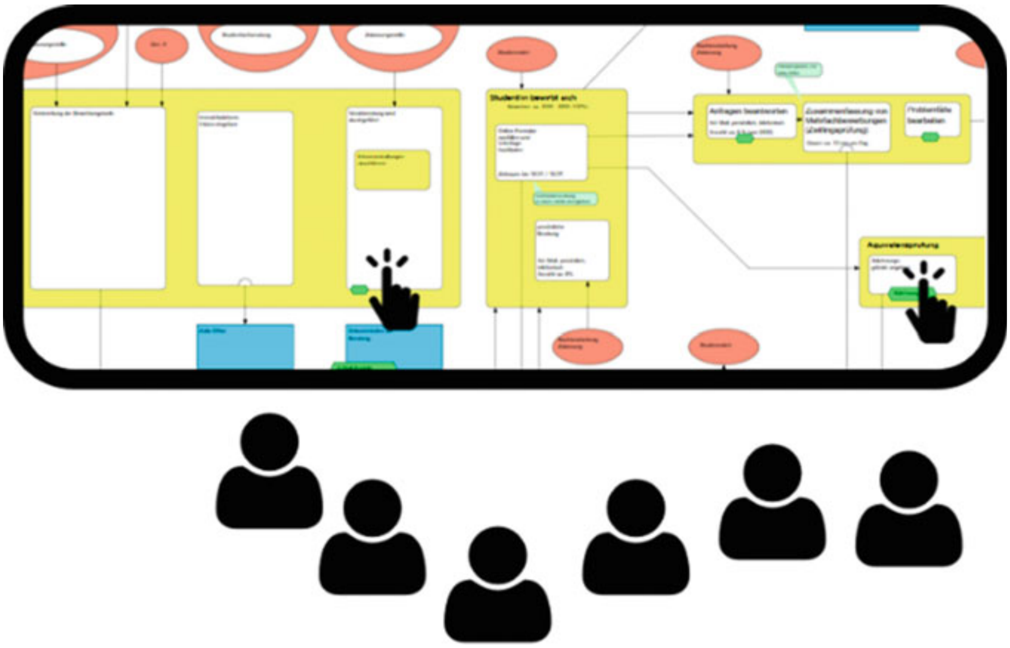

Fig. 12.5 Participants collaborating in a single group using a large interactive touch display wall

participate during the course of a workshop. Allowing participants to alter process models themselves also potentially increases their motivation to implement changes to a process that were discussed during a workshop [13, 28].

Intertwining different styles of collaboration

It is not sufficient to work with one of the previously described collaboration styles alone. It is rather necessary to intertwine them on demand. Since all devices used in our setting are connected to each other, it is easily possible to switch between different styles on demand [16]. The only requirement is to distribute an URL among the participants alongside their respective user credentials. Changing between styles can even be simplified by for example using personal mobile devices that are equipped with a camera. With support of a special app, a participant can then simply take a picture of a part of a model that they are interested in and the system could open the corresponding model and navigate to the part that was photographed [23].

The possibility to change between different collaboration styles aims at improving the flexibility of collaborative modeling workshops while providing participants with means to actively influence the content of process models.

The styles described before should not be considered as the complete spectrum of possibilities. It would also be possible to for example allow participants to continue contributing process parts (collaboration style 1) while others start consolidating the already existing elements (collaboration style 2).

12.3.3 The Role of the Facilitator and the Role of Participants in Collaborative Modeling

Current facilitation concepts in collaborative modeling focus on the facilitator being in charge of running a workshop, keeping track of its goals and subsequently managing the communication throughout a workshop. The facilitator is the central point of interaction with the process model throughout the entire workshop. The facilitator picks up verbal contributions by workshop participants, translates these contributions into elements of a modeling notation and integrates them into a process model.

The previously described collaboration styles (Sect. 12.3.2) still require the facilitator to be in charge of running a workshop and keeping track of its goals. The facilitator though will not have to continuously keep track of all communication and is no longer the only person interacting with a process model. Instead the facilitator will have to focus on guiding a workshop thus orchestrating different collaboration styles. This includes deploying different means of collaboration and deciding when participants should come back together after phases of parallel contributions and collaboration in sub-groups. The facilitator will still be required to serve as a modeling expert in certain cases. She will however not be required to make all changes to a process model since the participants can alter the process models on their own. The facilitator will rather serve as a modeling expert in cases where the participants cannot decide on how to depict certain aspects of a process in a model.

The role of the participants of a workshop also has to change. Since they are no longer limited to verbal contributions they have to learn how to use the interfaces proposed for the different collaboration styles. They also have to become proactive as it is necessary for them to choose a means of interacting with a process model that reflects their modeling expertise. They have to be able to determine when they require additional information by other participants (e.g. while working in sub-groups) thus supporting the facilitator in orchestrating collaboration.

Taking the aforementioned aspects together there has to be a shift of responsibilities. While the participants have to take more responsibility with respect to actively shaping a process model, the facilitator has to focus more on becoming a guide rather than being responsible for all changes to a process model throughout the whole workshop. Interactive surfaces provide opportunities for these changes to happen.

12.4 Case Studies: Collaborative Modeling in Multi Surface Environments

In the previous section we proposed three distinct collaboration styles alongside means to switch between them. In this section we will now describe examples of how we applied these styles in practice. We will report on the setting and the procedure as well as effects on the role of the facilitator. The examples serve as a proof of concept and a basis for deriving ideas on how to potentially improve collaborative business process modeling in multi surface environments.

12.4.1 Integrated Brainstorming

During the course of a project that aimed at supporting elderly people to live in their own homes for as long as possible we were faced with the task of designing a service where elderly people are accompanied during their weekly shopping. The service should be ordered using paper based forms that allowed for the ordering person to suggest other elderly people that would participate in a shopping trip. The service and the underlying process had to be designed from scratch since there was no process to build on in the first place.

We conducted multiple workshops where future stakeholders and domain experts jointly developed a model of a process that would then be used to establish the respective service. During these workshops we conducted multiple brainstorming phases and combined them with phases during which brainstorming contributions were clustered, discussed and aligned with respect to a process sequence [15, 22]. During the brainstorming phases each participant was given a tablet which they could then use to access an interface that the participants can use to contribute text (c.f. Fig. 12.6 top). The contributions were then automatically transferred into elements of a modeling notation and integrated into the process model (c.f. Fig. 12.6 bottom right).

After each brainstorming phase the facilitator of the workshop clustered the contributions by asking the participants whether or not an element fit at a certain

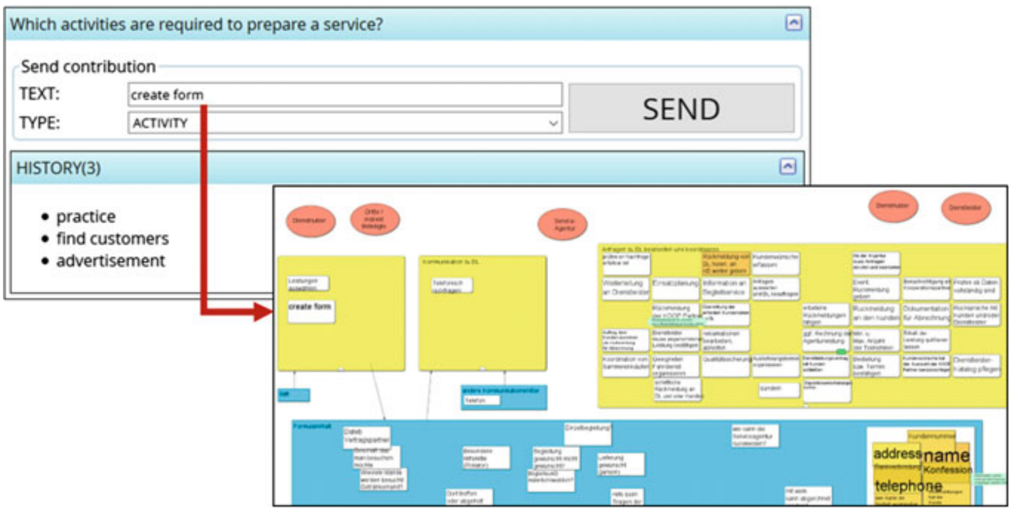

Fig. 12.6 Textual contributions (*top*) are transferred into elements of a modeling notation (*bottom right*)

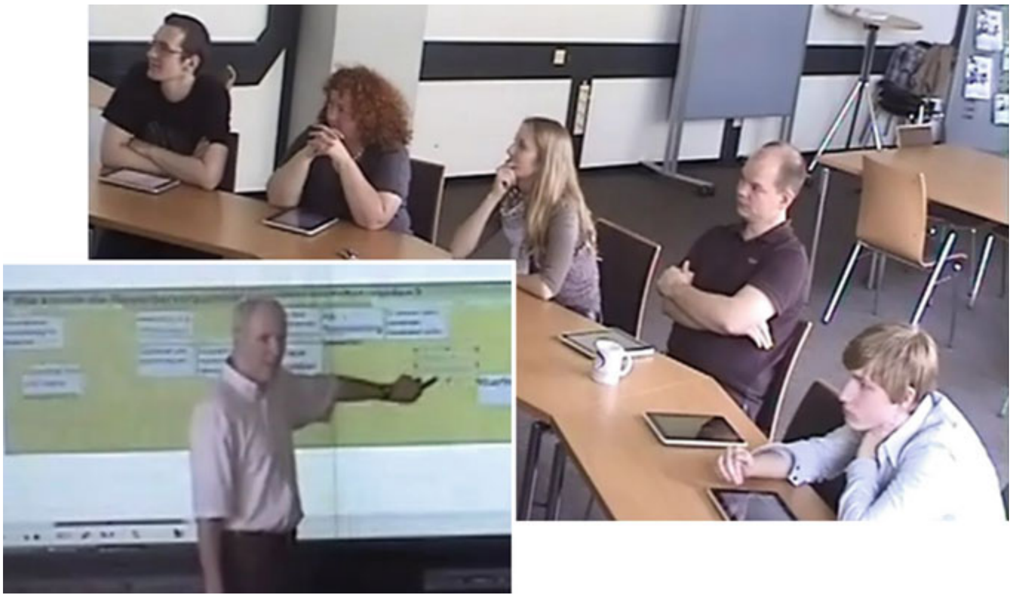

Fig. 12.7 Facilitator (*bottom left*) and participants (*top right*) during the course of a workshop

position (c.f. Fig. 12.7). If needed the facilitator changed the type of an element created new ones or altered existing ones to create clusters or created relations between the elements. During this phase the facilitator used an interactive touch display wall, which allowed them to move elements around, delete them or create new ones using touch gestures.

The workshops lasted about 2 h each. During those workshops we conducted 3 brainstorming phases of about 7 min. After each of these brainstorming phases we had a clustering phase, which lasted around 30 min each. In total we invited 11 participants. Their heterogeneity covered aspects such as gender (5 female, 6 male), age (range: 26 to 57 years), status (students, postdocs, research assistants, full professors, practitioners) and professional background. Some of them were involved as academics in the research on process design while others worked in nursing homes or as service providers. The participants were guided by a facilitator who was supported by another modeling expert who could operate the modeling tool on demand if something went wrong during the session for example with respect to the responsiveness of the touch interface. The workshops were video-taped and we tracked contributions by participants and interactions of the facilitator with the interface. After the workshops we conducted interviews with selected participants as well as the facilitator aiming at getting an insight into their experiences during the course of the workshops.

This setting thus combines collaboration style 1 with a phase where the facilitator asked the participants about their contributions and alters the model herself. During the brainstorming phases the participants could contribute in parallel while they were limited to verbal contributions during the following clustering phase. The facilitator was the only person that used the interactive touch display wall to move elements around, delete them, create new ones or put them into relation with each other. Our subsequent evaluation of the workshops provided indications that the possibility to contribute in parallel helped in overcoming some of the negative effects that are associated with typical workshop settings such as production blocking and evaluation apprehension [56]. Participants reported that the setting did not only allow them to develop their own flow of ideas. They also reported a strong sense of participation and mentioned that being able to contribute at any point in time fostered motivation. We also found indications that the participants developed a sense of ownership for the contributions since all of them were discussed, considered and integrated into the final process.

The setting also had some inherent limitations. Despite allowing the participants to directly contribute to a process model and thus become more active during parts of a workshop, it was not possible for them to alter or enhance their contributions in any way with their personal device. They were still dependent on the facilitator to carry out these tasks. Furthermore, participants could only contribute directly for short periods of time during the course of a workshop (about 20 min). Most of the time they were still limited to verbal contributions, which limited their flexibility of the participants to contribute at any point in time. The facilitator also reported some limitations with respect to the setting with the major one being that they found it hard to switch between phases. It always took some time for the participants to realize that they should stop contributing ideas and refocus on the facilitator.

All in all, we have to conclude that allowing parallel contributions by participants had a positive effect on collaboration mainly with respect to the participants feeling more involved and being more motivated to contribute. There are some limitations to this setting especially with respect to contributions only being possible at certain times. Furthermore, switching between phases should be improved.

12.4.2 Selecting Sections of Process Models by Taking Pictures

We developed a system that facilitates a seamless transition from working in one group to working in smaller breakout groups within the context of collaborative modeling workshops [16]. The system allows participants to alter a process model using a browser on a mobile device. The interface on the devices is coupled with the interface on a large interactive touch display wall which shows the same process model. In order to access a certain position within that model, the participants can use the camera on their mobile device, take a picture of the desired part of the process model. The system then automatically detects the correct process model, opens it on the mobile device and navigates to the detected position. Afterwards the participants can alter the process model using the interface displayed on their mobile device (c.f. Fig. 12.8). The system provides awareness features as it indicates the view port of other users that are currently connected with the model

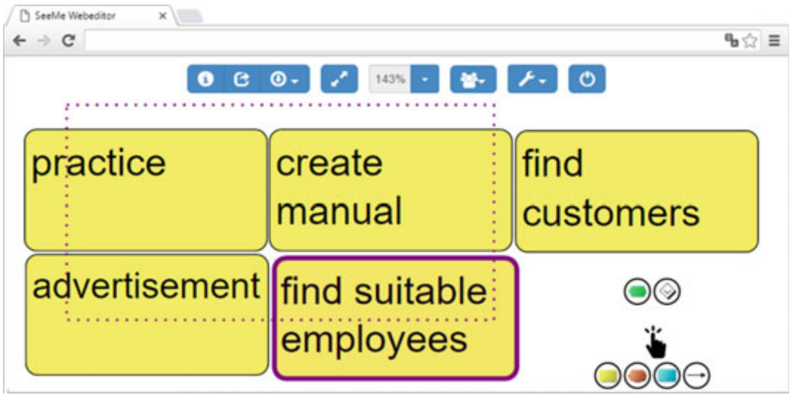

Fig. 12.8 Web based interface with flexible onscreen menu (*bottom right*). The *dashed area* shows the viewport of another user who also has selected an element (c.f. element labeled "find suitable employees")

(c.f. dashed rectangle in Fig. 12.8). The system also includes means of concurrency control as it locks elements that are selected by one user for all other users (c.f. element labeled "find suitable employees" in Fig. 12.8).

The system is operated via a touch interface that is based on gesture recognition. The system supports pinch gestures to zoom and stroke gestures to move the viewport of the model. Altering and creating elements is done by selecting the desired action within a location based menu that is activated by a single touch (c.f. Fig. 12.8 bottom right). In order to create an element a user can tap at any position on the screen and drag the respective element out of the menu that appears on the first tap. In order to use the system, the actors thus have to be knowledgeable about the modeling notation used.

In order to test the usability of the system and to identify means for improvement we conducted a study. The study was based on a workshop where 6 participants (5 male, 1 female) acted as process participants. They were asked to improve a prepared model that showed the process of how a renter should deal with a broken water line. All of the participants were knowledgeable about the modeling notation used and they were familiar with the process in question. The model of the process was purposely vague and contained errors both with respect to the spelling of certain model elements as well as with respect to process related aspects such as a wrong sequence.

The workshop lasted about 2 h and was divided into three phases. During the first phase a facilitator explained the model to the participants and they jointly decided on tasks that should be performed during the course of the following phase. Some tasks were very simple tasks (e.g. correcting spelling errors) while others were more complex (e.g. extending certain aspects of the process). During the following phase—which lasted for about 70 min—the participants split up into 3 groups and started working with the model. Using one tablet per group they took pictures of the areas of the model in which the respective task should be carried out and then started working on it using the interface displayed in Fig. 12.8. After each group had finished their respective tasks they came back together and discussed the respective changes each group had made to the model. This phase lasted for about 18 min and was guided by the facilitator. The setting thus covers the aspect of intertwining different collaboration styles while including collaboration style 2.

After the workshop we conducted a group interview and both participants and the facilitator were handed questionnaires after the workshop. The questionnaires aimed at assessing the perception of the participants on the system and the setting. They covered aspects such as whether or not the system allowed the participants to be more active during the course of the workshop, whether or not the system fostered discussion among them and whether or not the system increased the efficiency of the workshop. The participants had to rate each aspect on a scale of 1 ("strongly disagree") to 5 ("strongly agree"). The questionnaire for the participants also contained questions based on the heuristics described by Nielsen [58] in order to assess the usability of the system.

Evaluating the questionnaires and the group interview we found that the participants as well as the facilitator perceived the system to support workshop participants to be more active during the course of a workshop (likert scale: median 4 out of 5) thus increasing their sense of participation. With respect to whether or not the system fostered discussion among the participants the verdict was not so clear (median 3). We thus assume that not all participants perceived the system to foster discussion. We found a similar situation with respect to whether or not the system increases the efficiency of a workshop. A median of 3 out of 5 indicates that some participants perceived the system to increase the efficiency of the workshop while others did not. Furthermore, the participants positively rated the usability of the system (median 4 out of 5) with the exception of how the system handled errors (median 2).

During the subsequent group interview the participants positively mentioned the possibility to use pictures as a means for navigation within a process model. They said that they found it "surprisingly useful" and that it allows for a "seamless transition" between working on the large display wall and on a tablet. They also positively mentioned the previously described awareness features. They said that it was "easy to follow what others are doing" and that the features were "not distracting". The participants however mentioned that keeping track of the tasks was difficult since there was no indication in the model itself what the task was. They thus had to keep track of the tasks themselves. The participants also mentioned that operating the interface on the small tablet display was hard sometimes especially when operations had to be conducted that require a certain precision such as connecting elements through arrows.

The facilitator mentioned during the subsequent group interview that different group speeds could potentially be hard to handle during the course of a workshop. She thus suggested for the system to allow groups to hand over tasks to others.

All in all, we can conclude that while the system did not bring a considerable advantage with respect to speed, the participants as well as the facilitator perceived it to allow them to become more active during the course of a workshop. Furthermore,

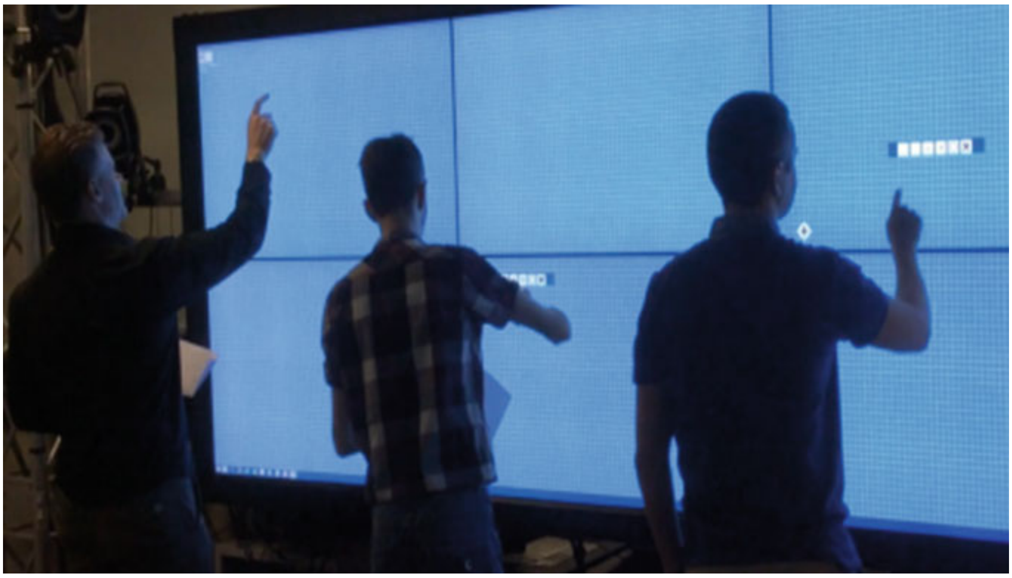

Fig. 12.9 Three workshop participants collaboratively using the CubeBPM system

the photos allowed for a seamless transition between working in one large group and working in smaller subgroups. The system still requires some improvements with respect to usability (error correction as well as handling small elements on a touch display) as well as with respect to supporting group dynamics (e.g. tying tasks and model changes together as well as handing over tasks between groups).

12.4.3 CubeBPM—Collaborative Modeling on Interactive Large Display Walls

Aiming at assessing how large interactive touch display walls can influence collaborative process modeling, we developed the CubeBPM system [53, 59]. CubeBPM allows multiple actors to draft models collaboratively using a large interactive touch display wall (c.f. Fig. 12.9) thus providing them with direct access to process models and the possibility to directly manipulate them. The system runs on a large single integrated touch display,[2] which consists of 6 almost seamlessly, connected panels (2 rows by 3 columns, c.f. Fig. 12.9). The tool can run on large segmented displays via synchronized and networked hardware, to produce a highly scalable solution to cover large wall display systems (e.g. QUT Cube [60]).

[2]See CubeBPM demo video: https://youtu.be/OuEHsL9vCR8.

CubeBPM implements the majority of the control perspective BPMN[3] grammar including: swim lanes to represent actors in processes, gateways to represent decision points, activities, and event types [24]. CubeBPM is operated via an interface that is based on touch gesture recognition. The gestures used were devised from previous research into the use of touch gestures on digital tabletops for process modeling [20]. The underlying design rationale was to create an interface that was easy to use, fast to learn and that could be used by multiple actors who work at the same model in parallel. We thus focus on simple touch gestures (e.g. crossing an element out to delete it or drawing a line between two elements using two fingers to connect them to one another). The system also offers location-based flexible menus that provide actors with basic modeling functions at disparate locations. These menus are accessible via double tapping (c.f. Fig. 12.9 top right). In order to create an element, actors have to select the elements they want to create and drag the element out of the menu to the screen (c.f. [53] for more information on the system and the gestures used). Using CubeBPM requires actors to be knowledgeable about the modeling notation used (BPMN) since there are no functions implemented that relieve actors from the necessity to translate their contributions into elements of a modeling notation.

In order to test the feasibility of the CubeBPM we conducted preliminary studies during which 3 groups of 4 participants were asked to create a process model based on a textual description. All of the participants were graduate students that were attending a class on BPMN and they were thus knowledgeable about the modeling notation used. The process in question is the procedure of shopping in a retail store. Each experiment was set to last for about 30 min with an additional preparation time of roughly 10 min. During this preparation the facilitator showed the participants how to operate CubeBPM and gave them some time on their own to familiarize themselves with the system. Then the facilitator opened a predefined model that contained all elements necessary to model the described process and asked the participants to assemble them so that the model fits the description, which required them to alter the sequence of elements by moving them around and connecting them to one another. The participants were allowed to add elements when they feel it is necessary. We provided the participants with a predefined set of elements, as typing in text is time consuming on vertical display walls. The facilitator only served as a guide who made sure that the participants followed the pre-planned procedure of the workshop. The facilitator also supported the participants when they had questions relating to the usage of BPMN as a process modeling notation (e.g. how to visualize a certain process step within the model). Each workshop was videotaped and we tracked interactions with the CubeBPM interface. Afterwards we coded the videos using the free tool ELAN.[4]

The previously described setting can be considered an incarnation of collaboration style 3 and can thus serve as an example for a convergence phase. All

[3]http://www.bpmn.org/.

[4]https://tla.mpi.nl/tools/tla-tools/elan/.

participants could alter the process model at any time in any way they saw fit using a touch gesture based interface on a large interactive touch display wall. Since all participants were knowledgeable about the modeling notation used the facilitator only had to guide them through the course of the workshop. The facilitator did not have to assist them with respect to using the modeling notation.

Analyzing the material gathered during the course of the workshop we found that almost all participants used the touch interface provided by CubeBPM in order to alter the model. Changes to the model mainly focused on altering the sequence of elements which included moving them around on the screen and connecting them. Sometimes participants also created new elements.

The extent to which single actors used the touch interface expectably differed hugely between individual participants. Some participants used CubeBPM extensively on their own while others only rarely altered the model. We also found occasions during which participants asked others to carry out changes to the model rather than doing it themselves. The participants that carried out the changes thus took over duties that are normally associated with the role of a modeling expert. How the participants used CubeBPM and whether or not they used it at all was entirely left to them. Considering the aforementioned observations that almost all participants did use CubeBPM themselves together with the fact that they were not obliged to do so consequently leads us to the assumption that CubeBPM positively influenced the motivation of the participants to actively alter a process model and thus to participate in process model development.

With respect to collaboration we found all possible kinds of different constellations among the groups. Sometimes all participants worked together while it also happened that they split up in groups of two or that a single participant left the group to work at a different part of the model while the other participants stayed together. There even were occasions where all four participants worked individually on different parts of the process model. Changes between different group constellations happened on demand without explicit coordination.

Regularly different participants altered the process model at the same time. These changes however were all independent to one another. It never occurred that participants interacted between different groups (e.g. handed over elements to another group or another participant). Furthermore, we also observed participants stopping discussions when other participants made changes on a different part of the process model. This leads us to the assumption that modifications are noticed even by participants that do not contribute to the modifications directly.

We also observed large differences between the different groups. While one group stayed together for almost the entire course of the workshop, another group only did so for about 50 % of the time. During the remaining time they mainly worked in pairs or in a group of three with a single participant working on a different part of the process model at the same time. These differences in the way participants collaborated also had a profound effect on the time it took them to assemble the process model. The group that only stayed together for about half of the time was twice as fast as the group that stayed together for almost the entire time. This difference cannot entirely be attributed to the way they collaborated but it provides an indication that working in flexible group constellations can have a positive effect on workshop efficiency.

Our analysis pointed out some limitations of this way of collaborative process modeling using CubeBPM. First participants have to be knowledgeable about the modeling notation used. This was not a big problem during the course of our study since the participants all had used the modeling notation before and since the process did not require them to create complex structures. There however were occasions during which participants asked the facilitator whether or not they had used the modeling notation in the correct way. We expected this to happen more often when the complexity of the models increased. Second we found a huge gap with respect to activity of participants during the course of the workshop. Some participants were active almost all the time while others rarely contributed (verbally or directly). This behavior can at least partly be attributed to the fact that it was entirely left to the participants whether or not they wanted to contribute.

All in all, it can be stated that allowing participants to alter a process model using a large interactive touch display wall affects the way they collaborate. The setting affords participants to actively contribute to process modeling and affects the way they collaborate since it allows for different groups to form on demand. The setting potentially requires more guidance by a facilitator since not all participants contributed or could contribute equally.

12.5 Discussion

The previously described case studies provide indications for positive as well as negative effects of using interactive technology in different collaboration styles in the context of collaborative business process modeling.

First, we found all styles to increase the perceived **efficiency** of a workshop. This can partly be attributed to the fact that participants were not limited to verbal contributions. They rather could directly interact with the process model in all of the styles which subsequently eliminated the facilitator bottleneck. We thus assume that using interactive technology positively influences the participants' perception of efficiency.

Second, we found all collaboration styles to **increase the sense of participation** for the participants which positively influenced their **motivation to participate** during the course of a workshop. This again can mainly be attributed to the fact that all participants could directly alter the process model at any point in time. It should however be noted that it was not possible for participants to alter contributions in collaboration style 1. This was perceived as being not adequate by the facilitator and the participants alike.

Third, we found for collaboration style 3 to increase the **sense of ownership** for the process model. We did not find indications for this during collaboration style 1 and 2. This might be attributed to the fact that a sense of ownership for the process model as such can only be developed when:

- A common understanding about a process is reached,
- Participants agree about how to alter a process and
- Participants feel that their input has been valued and considered.

During collaboration styles 1 and 2 it is only marginally possible to reach a common understanding or agree to changes to a process since every participant only works on certain aspects of a process. In collaboration style 3 however it is possible to reach a common understanding about the process as a whole and agree on changes.

It was not only the possibility to directly interact with all parts of a process model that positively affected the perception of collaboration of the participants. There was also the possibility to focus the attention to those **aspects of a process model that participants were interested in**. This became evident while testing collaboration styles 1 and 2. Both styles allowed switching between focusing on the large touch display wall in order to gain an overview and focusing on smaller devices in order to work on specific aspects of a process model. While testing collaboration style 3 we found multiple occasions during which participants collaborated in different constellations on different parts of a process model that they were interested in.

There were also some **drawbacks** with respect to the different collaboration styles which can subsequently serve as a basis to improve the concept. First we have to note that despite the possibility to alter a process model at any point in time **some participants remained passive**. This became especially evident in collaboration style 3. Some participants decided to not interact with the displayed process model despite the possibility to do so. A facilitator who particularly asks those participants to contribute can potentially help in these situations.

Furthermore, we found **coordination** to be an issue for different settings. The facilitator reported that it was hard to decide when to bring groups back together. The participants sometimes found it hard to identify which tasks had been assigned to them and which had been assigned to a different group. This leads us to the conclusion that the system should provide better support for coordination between participants as well as between participants and the facilitator.

The previously described studies also have some inherent **limitations**. First each collaboration style was tested individually and only in one setting. Furthermore, the number of participants as well as the tasks and time for the workshops varied between each setting. This limits the generalizability of the results. Finally, the interfaces used were not the same for each style.

Despite these limitations the studies can still serve as a prove of concept that the proposed collaboration styles can positively influence collaborative modeling workshops We found indications that the collaboration styles and their respective setting indeed have a positive effect on the efficiency of workshops. We also found the settings to increase the participants' sense of participation and ownership, which potentially affects their motivation to contribute during workshops. It can thus be stated that multi surface environments can positively affect collaboration and collaboration outcomes in a context of collaborative process modeling. There is however a necessity for future studies especially with respect to intertwining different collaboration styles within a single workshop in order to further explore the potential of multi surface environments in the context of collaborative modeling.

12.6 Conclusion and Outlook

Current approaches in collaborative process modeling are strongly dependent on a facilitator and limit participants to verbal contributions. This subsequently limits collaboration among participants and potentially affects the resulting process models in a negative way. We identified interactive surfaces and multi surface environments as a way to overcome the limitations of current workshop approaches and presented an environment that aims at allowing participants to become more active during workshops. We proposed three distinct collaboration styles and tested each of them individually. Results from the studies provided indication that interactive technology potentially improves involvement by participants, speeds up workshops and subsequently improves the quality of collaboration outcomes. We also identified means of how to improve the proposed approaches mainly with respect to approaches to intertwine them.

In the future we are planning to conduct further studies on the impact of interactive technology on collaborative modeling workshops. We are particularly interested in how they change collaboration among participants. We aim at identifying patterns of collaboration that can subsequently be supported in multi surface environments. The concept should be extended to support a larger variety of ways to collaborate. We will continue to explore different ways of facilitation thus aiming at creating a more effective collaboration between facilitators and workshop participants.

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