Multi-touch Table or Plastic Wall? Design of a Study for the Comparison of Media in Modeling

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Abstract. An important aspect of participatory enterprise modeling is the work in a group. However, does the collaboration of the group members change depending on which medium is used to generate the models? Are there for example differences in the group's behavior when working with a plastic wall, similar to a whiteboard, or with a multi-touch table? Based on the state of research and theoretical foundations of group work as well as previous research, relevant research issues are raised and an experimental design will be described in order to examine possible differences in the group work depending on the medium. Relevant aspects will be forms of cooperation, i.e. verbal and non-verbal contributions of the participants, but also territorial behavior and group performance.

Keywords: Multi-touch-table · Plastic wall · Enterprise modeling · Intermedia comparison

1 Introduction

When an enterprise is faced with changes such as new products, new IT-systems, new competitors or new legal regulations, it is important to know the enterprise as a whole with all its processes, structures and dependencies. In this regard, business process modeling and enterprise modeling provide important tools. They can visualize the as-is state of an organization and they often provide the only means of revealing causes for problems and potentials for changes at all [30]. To draw maximum benefits from modeling, it is useful to include the persons concerned in the modeling process, i.e., persons in charge of individual departments and IT managers. Participative modeling follows exactly this approach. It ensures that people actually concerned actively participate in model development and the models, as a result, achieve higher acceptance. To support the domain experts of the enterprise in modeling, persons providing expertise in the modeling language are invited as moderators (so-called facilitators) to lead the discussion and to document the results in digital form [28]. Thus, the group work is an essential aspect of process and enterprise modeling.

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In a participative modeling session, very different tools can be used. [30] describe the use of plastic walls as an appropriate way to motivate the persons involved to active participation. Usually, the plastic wall is attached to a wall where it can be written on and colored cards can be added, similar to a whiteboard. However, using the plastic wall requires the moderators not only to lead the discussion but also to take care that all group members follow the notation rules of the modeling language used. Finally, moderators transfer the results into digital form. Therefore, it would be preferable to use a modeling tool facilitating the observation of notation rules as well as the documentation of the results without losing the participative character of the modeling session. Multi-touch tables, also called tabletops, enable several users to interact simultaneously with a software by touching the surface [16]. Therefore, they could be used as an alternative tool to the plastic wall for participative modeling. Since this is a computer-aided tool, a development environment can be provided for modeling which facilitates the application of the modeling language. Above this, the models can be stored digitally already during the session.

This leads to the question to what extent a multi-touch table in its use for modeling differs from the traditional plastic wall. An empirical study shall clarify the differences between both tools in participative modeling. Particular emphasis is placed on which differences the media cause in the group work and if the specific way how the tools are used for the group work differs.

The goal of this article is the design of an experiment, which allows the comparison between multi-touch table and plastic wall in collaborative modeling. Because group work is the central issue of the study, the corresponding state of research as well as related theories are briefly described in Sect. 2. Concerning multi-touch-table usage, several studies have been conducted. Section 3 shows, however, that these studies are usually either exploratory or, even more often, of a descriptive kind. Studies with an experimental design comparing multi-touch tables with media such as paper or PCs, do not yet provide a satisfactory picture of the group work with tabletops. On the one hand, they do not provide a sufficient basis to draw conclusions for the comparison with a plastic wall, and on the other hand, they show partially contradictory results. After presenting the theories and the state of research, concrete research questions to be answered through the study will be deduced. In Sect. 4, the research design of the study will be introduced.

2 Group Work

Participative modeling is a classical group work in which domain experts and methodology experts work on a shared task. In the literature, different features may be found to characterize groups. A group is referred to as three or more persons interacting directly and over a longer period of time. According to [20], group phenomena actually emerge only from a number of at least three persons. Within the group, different roles evolve over time, such as the role of the leader or the specialist. In order to know how to behave in their working with others, common standards, values and goals have to be determined. The group members typically perceive and present themselves as belonging together to the outer world [13, 25, 32].

Group work can lead to numerous advantages, especially when tasks are too complex to be solved by a single person. However, in many cases it was shown that the performance of a group can be lower than the performance obtained by its members separately. Thus, the actual performance deviates from the potential performance in such a way that a loss in performance occurs due to group processes. This depends, amongst others, on the kind of the task the group is working on [13]. According to [29], tasks can be distinguished by their possibility to be split among the members, whether quantity or quality is aimed at and in what way the group members contribute to the overall result. Gains and losses by group processes result from motivation, individual skills and coordination [10]. Social facilitation and social compensation are examples of process gains in the area of motivation [32]. In social facilitation, the mere presence of others makes a person work harder than being alone. We talk of social compensation when a stronger member of the group tries to counterbalance performance deficits [10, 32]. Thus, if some members of a modeling session could contribute less due to a possible lack of knowledge, another member with a higher expertise would work even harder than working on this task only by himself in order to compensate the deficits of his colleagues.

However, process losses can also occur due to a lower motivation of the group members. So-called social loafing occurs when group members perform less than working alone because they cannot see their own contribution to the overall solution [10, 15, 32]. If the individual input is made visible for the group members, motivation will rise again. This can even lead to the so-called Köhler effect [14], a form of social facilitation, where a group member works harder to avoid being responsible for a lower group performance [10]. If colors have not yet been assigned a certain meaning in the notation of a modeling language, the contributions of individual group members could remain identifiable by the colors of their cards or pens they use.

If group members deliberately perform less believing that they have only little influence on the result of the group work, it is called free-riding effect [10, 13]. A participant of a modeling session should not get the feeling that his contributing or not to a solution is irrelevant. This could happen in a modeling session, for example, when modeling is done at the computer with only one mouse and one keyboard, as in a study of [24]. The authors found that oral and physical contribution in the sense of inputs were distributed significantly unevenly among the group members using a laptop only compared to the use of a multi-touch table.

Process losses and gains in the area of individual proficiency can result, for instance, from cognitive limitation and cognitive stimulation respectively [10, 13]. In enterprise modeling, ideas and knowledge are partly collected in the style of brain storming according to [21]. On the one hand, the statements of one group member can direct the others towards a certain topic and thus limit their range of thoughts. On the other hand, these statements can inspire new ideas, which they would possibly not have produced otherwise [10].

Process losses can also occur due to difficulties in coordination. During brainstorming, for example, group members have to let one another speak out before they can present their own ideas. Empirical studies have shown several times that actually fewer ideas were produced during brainstorming than when group members recorded their idea by themselves [18]. Process gains in the area of coordination could not be stated so far [10].

3 Multi-touch Table as a Tool in Group Work

Because of their direct and natural handling and their very good visualization options, multi-touch tables are introduced in many different areas, e.g. as teaching tool [22], in medicine [17], and in architecture [19]. The size of the medium and innovations with regard to data input [16] enable several persons to operate the user interface simultaneously. Therefore, they are especially useful for tasks concerning collaborative designs and modeling. There are some studies describing how public places are designed using a multi-touch table [19, 24] or how software is developed by several persons drawing UML diagrams [5]. They have also been approved for tasks implying more generally creativity and the collecting of ideas as used in brain storming [4, 26].

In this section, previous findings concerning territorial behavior and awareness (Sect. 3.1), behavior in cooperation (Sect. 3.2) and performance (Sect. 3.3) are presented.

3.1 Territorial Behavior and Awareness

In a study with students being asked to assemble pieces of a poem like a puzzle, [23] put the focus on the size of tabletops. They found out that even larger groups in their study would not profit from a larger table. The test persons using the larger table were neither faster nor did the size of the table influence the division of labor or the subjective evaluation by these persons. The authors partially explain this by the setting up of territories on the table. [23] always observed three kinds of territories for the users: one area within reach of the respective user only, one area within reach of the respective users as well as for all the other users, and one area in reach of the other users only. [27] describe a similar territorial behavior mentioning a personal area that no other user has access to without being asked, one area accessible by the entire group and another area accessible for the respective user and their neighbors. The latter serves primarily to store work objects temporarily. Both [23, 27] concluded that the sense of responsibility for objects decreases with a growing distance between them and the users. Therefore, a larger table may lead to a larger area of the table that no user feels responsible for.

Nevertheless, a multi-touch table that is big enough for the users to set up their private spaces offers certain advantages. [9, p. 107] emphasize the importance of awareness defining it as “an understanding of the activities of others, which provides a context for your own activity.” In order to coordinate the group work, it is essential for everybody to know who is doing what and why. A private space on the multi-touch table enables the user to try things apart from the group whereas the other group members still can have a look over his shoulder. In this way, the group members are kept informed about the activities and can possibly ask questions to their neighbors or provide help [27].

An outsourcing to external devices like tablets or other mobile devices may seem obvious. The results of a study from [8] suggest, however, that a group is most encouraged to cooperate when using a tabletop exclusively. [27] also dissuade from establishing fixed areas on a multi-touch table observing that the territories continuously

change. There are also design approaches, which provide for special features of the user interface to ensure awareness (see [11], for example). Plastic walls, on the contrary, offer only limited possibilities. The setting up and the dynamic change of territories on the plastic wall seem rather unlikely, since changes and corrections are more complicated. [22] showed that children preferred tabletops to paper for solving tasks, because mistakes could be corrected more easily. Similar results can be found in studies from [3] comparing paper and multi-touch table for developing UML diagrams and in interviews by [24] on using tabletops, beside other tools, for designing a park. Thus, tabletops seem to offer an advantage through their flexibility. In sum, awareness is an important aspect for the coordination among the group members and thus for the entire collaboration. It might be supported by offering areas on the work surface where individuals may try out designs or models on their own, but which are still visible to the other group members.

3.2 Behavior in Collaboration

In studies dedicated to the collaboration at multi-touch tables, the authors are primarily interested in how close the cooperation of the group member is, whether the persons work in parallel and if the contributions are evenly distributed. These contributions mainly refer to oral contributions, gestures or interactions with the user surface to work on the task. With their experiments, [4] showed that less oral contributions and gestures were produced during a brainstorming task using a tabletop than those using a table covered with paper, even though the authors provided software with attractive features for the multi-touch table. Flipcharts, however, scored lower than tabletops. [4] concluded from their study that the arrangement of the work surface essentially influenced the collaboration, whereas the attractiveness of the tabletop with its features provided were rather distracting. [3] also compared in first place the use of paper and pen with multi-touch tables and concluded that the test persons spent a larger proportion of time working together closely. In contrast, the group members using paper spent a larger proportion of time working on their own. In another study, [6] compared the use of PC and multi-touch table. They examined how evenly the contributions in the form of inputs to generate UML state diagrams were distributed in a two-person team. The contributions were significantly more balanced at the tabletop. Moreover, they stated that the collaboration was closer at the multi-touch table and that at the PC, it was more likely that one person was working while the other person was only watching. [24] came to a similar result in experimentally comparing laptop, tabletop, and tabletop connected with boards and tangible objects by which one can additionally interact with the tabletop. The authors focused on interactions with the user interface as well as oral contributions. Tabletops, especially in connection with tangible objects, seem to foster collaboration and obviously make it easier to invite other users to participate.

The authors noticed that persons participating less by oral contributions did compensate this by more pointing and gesticulating when using a more tangible interface. However, this could be an advantage of the plastic wall, because the persons operate with objects like colored cards and can thus draw attention to themselves. In sum, most studies existing on the subject compare multi-touch tables with paper media or PCs.

Plastic wall could turn out more flexible, however, since it allows small corrections and the media seems more tangible by using of additional auxiliary tools such as cards.

3.3 Performance

Some of the above-mentioned studies comparing multi-touch tables with other media also investigated possible differences in group performance. Regarding the performance, the authors were mostly interested in how much time a group needed to tackle a problem, as well as the quality of the solution. [2] reports that test persons needed more time to elaborate UML state diagrams using a tabletop than using the PC. According to the author, this is due to the more difficult input of text using a touch keyboard, since the test persons performed twice as fast with a common PC keyboard. On the other hand, the quality of the solutions was significantly higher at the multi-touch table, as measured by two software experts on a scale of ten. [4] did not find any differences in the amount of ideas produced in the group when either using flipcharts and tables covered with paper or multi-touch tables for brainstorming tasks. However, the authors also evaluated the categorization of the ideas produced in the group with the paper table obtaining the best results.

While [12] did not try to compare multi-touch tables and other media, they still found out that the quality of a solution for an analysis task was higher at the tabletop when the group worked more closely together.

4 Research Questions and Method

4.1 Research Questions

The previous sections showed that empirical investigations regarding multi-touch tables were mostly of a descriptive or exploratory kind. Experimental studies in this area allow predictions regarding the comparison of plastic wall and multi-touch tables only to a small extent. The tasks assigned to the test persons were not always exactly comparable with the issues of enterprise modeling, even though some elements, such as brainstorming, can be recognized. Above this, often groups of only two persons were examined in the studies, e.g. in [5, 8, 12]. According to [20], though, group phenomena emerge only at a number of at least three persons. Furthermore, some of the empirical findings are contradictory. Moreover, the plastic wall is not quite comparable to the media which were contrasted with multi-touch tables in the studies presented.

Since the previous results in collaborative modeling at multi-touch tables have to be considered still insufficient, we suggest an exploratory study in order to generate hypotheses on differences in the use of multi-touch tables and plastic walls. To further define the investigated area, concrete research questions have to be elaborated. As mentioned before, the main issue of the study is collaboration, whereas it is of interest how well and how closely the group members work together. Previous studies considered how evenly the contributions were distributed among the participants. To get indications for possible process losses such as coordination losses or motivation losses, subjective individual contribution should also be scrutinized. However, it would be

particularly interesting to find out if and how the relevant medium is used for collaboration: E.g., do group members gesticulate with cards, or do they move objects on the multi-touch table to illustrate their ideas? Hence, the first research question arises with the following subquestions:

1. Is there a difference in participative enterprise modeling between multi-touch table and plastic wall in group collaboration?

(a) Are there differences in the actual distribution of the contributions?
(b) Are there differences in the distribution of the contributions as perceived by the group members?
(c) Are there differences in the use of the media for the collaboration?
(d) Are there differences in the motivation of the group members depending on the medium?
(e) Are there differences in the coordination of the group members depending on the medium?

It is important for the collaboration that the group members are informed about what the others are working on at the moment. In this context, we use the term awareness. Whether the group members feel informed, however, can be best assessed by asking them. For this reason, subjectively perceived awareness will be of prior interest. But how do the group members notice what the others are currently working on? Our study will also deal with this question. To this end, the notion of personal working areas that are nevertheless recognizable to the others could be probably helpful. This could also be interesting for future investigations, since motivational aspects could play a role here. If one group member realizes, what, and above all, *that* others contribute to the solution, it is possible that this group member wants to avoid "lagging behind". The group member could also realize the weaknesses of the others and try to support them in the sense of social compensation. Activities in one's own working area could also contribute to social facilitation, i.e., the own performance is rising because it is visible for the others. This cannot be explained completely by the first study, yet it could provide first indications. For this reason, both awareness and the setting up of territories will be explored with the following research questions:

2. Are there differences in participative enterprise modeling between multi-touch table and plastic wall regarding the setting up of territories?
3. Are there differences in participative enterprise modeling between multi-touch table and plastic wall in the perceived awareness of the persons in relation to the other group members?
4. What kind of information is important to the group members to stay informed about their colleagues when using plastic wall and multi-touch table, respectively?

As mentioned, multi-touch tables have been compared to media such as PCs, paper tables and flipcharts so far. Paper tables and flipcharts are only partly comparable to a plastic wall. As with flipcharts, additional cards can be used. The orientation of the work surface is similar as well, although at the plastic wall, corrections are possible – although not as easy and as fast as on the multi-touch table. Therefore, it is not exactly predictable

how multi-touch table and plastic wall will differ regarding their performance operationalized through speed and quality. This results in the last research questions:

5. Are there differences in participatory enterprise modeling between multi-touch table and plastic wall regarding the group performance?

   (a) Are there differences in the task duration?
   (b) Are there differences in the quality of the solution?

4.2 Method

As mentioned in the previous section, an exploratory study is suggested for the empirical comparison of multi-touch table and plastic wall. This means that at first no hypotheses will be formulated, since previous empirical findings and theories did not provide sufficient knowledge. The study rather aims at exploring the research area and, if possible, setting up hypotheses which have to be tested in future explanatory studies [7].

Sample and Procedure. For the study, a group size of three persons is chosen since group phenomena emerge only from a number of at least three persons [20]. In practice, usually more persons concerned should be involved in the enterprise modeling [30]. However, the size of the multi-touch table available for the study is a limiting factor since everybody should find enough space at the table.

As test persons, students of Business Informatics and Computer Science familiar with the modeling language 4EM are to be recruited. The first goal is to provide a homogeneous sample to minimize influences that could possibly emerge from sample properties. Nevertheless, the test persons should the target group as well as possible. We chose an experimental design: The experimental design is the only possibility to prove causal relationships [7]. An independent variable will be manipulated in order to measure its effects on one or more dependent variables. In order to measure the effects of the modeling tool (independent variable) on dependent variables such as the performance (measured by speed and quality) or the collaboration, the modeling tool itself will be manipulated in the first place: modeling tasks are carried out either with the plastic wall or the multi-touch table. After the randomized selection of the work tool, the group is asked to solve a task from the area of goal-oriented modeling and problem-oriented modeling. To motivate the test persons, it is announced that their results have to be officially presented afterwards. We suggest a repeated measurement design where the groups are supposed to work at two different dates on one task respectively. In case the same group works on two tasks, learning effects are probable. In order to minimize this influence, the order of the employed media will be randomized for each group, i.e., it will be randomly decided whether a group will use the plastic wall first and then the tabletop or vice versa.

For measuring the dependent variables, it is necessary to employ several survey instruments. These are behavioral observations on the one hand and the survey with semi-structured interviews as well as questionnaires on the other hand. Table 1 shows all dependent variables in summary arranged according to the research questions and how they are to be gathered.

Table 1. Overview of the dependent variables and how they are measured arranged according to the corresponding research questions.

Dependent variable	Data collection method
1. (a) Contributions (type, distribution etc.)	Observation
1. (b) Perceived contribution	Questionnaire
1. (c) Media usage for the contributions	Observation
1. (d) Motivation	Questionnaire
1. (e) Coordination	Questionnaire, interview
2. Territorial behavior	Observation
3. Awareness	Questionnaire, interview
4. Awareness-indications	Interview
5. (a) Task duration	Time measurement
5. (b) Quality of the solution	Evaluation by means of Experts Criteria

Observation as Method of Data Collection. As mentioned above, we intend to apply several methods to collect data. However, here, we will concentrate on presenting how we plan to implement the data collection by means of observation, because it appears to be the most important method of exploring the collaboration in the group working either with a plastic wall or a multi-touch table. In similar studies (e.g. [4, 5, 12]), the authors observed their tests persons with video cameras to investigate details of their collaboration. Usually, more than one observer is needed in order to raise the reliability, i.e., the measuring accuracy [7, 20]. This means that several observers have to be recruited. These persons have to undergo an intensive observation training first. With the help of video recording, the procedure can be significantly simplified, since the observers can watch the recordings independently from one another and as often as necessary.

Scientific, structured observations are made using an observation scheme [7, 20]. While [5, 12] were coding the observed behavior according to a scheme by [31], which was set up in an inductive way by the researchers, it is recommendable to employ a more established observation scheme for group work like the interaction process analysis by [1]. It divides actions into 12 categories, such as “agrees” and “asks for opinion.” Finally, an observation scheme can be used to determine how often a certain kind of behavior occurred on group level or personal level.

It is interesting to learn whether the individual actions of the participants are concrete contributions to the solution, whether they are verbal or non-verbal and from whom exactly they originate. In this way, the balance among the members’ contributions can be analyzed. Furthermore, the way in which the respective medium is used for these actions can be analyzed. Specific ways of usage can thus be determined which may be transferred from plastic wall to tabletop, or completely new ways of usage at the tabletop may be observed.

In order to capture the possible set up of territories on the work surface, a procedure following [27] will be chosen. For the observation, the work surface will be divided into several fields by a (virtual) grid. Using the video material, it will be analyzed in

which section and how often the single test persons work – measured by the frequency of the interactions with the user interface. This should show whether personal areas emerge where a particular test person works primarily.

4.3 Lab Environment

The experiments will be performed in the "enterprise modeling observatory" at Rostock University. This lab consists of various enterprise modeling tools and a lab room equipped with cameras and recording tools for observing modelers, decision makers and other enterprise stakeholders in using tools, modeling languages, notations and software systems. The purpose of this lab is to contribute to a better understanding what kind of role distribution in modeling teams, notations or modeling languages, human computer interaction and software functionality supports what kind of enterprise architecture management task in the best way. All modeling phases from initial modeling on plastic to modeling with specialized enterprise modeling software are supported for teams of up to six persons. Most relevant equipment of the observatory for the planned experiment is:

Table 2. Equipment in the modeling lab and supported modeling phases

Phase	Equipm.		
	Established industrial tools	Tools with innovation potential	Documentation and analysis tools
Scoping and goal modeling	Whiteboard, moderator's case	SmartBoard, Mobile Modeling	Video recording
Initial conceptual modeling	Whiteboard, moderator's case	SmartBoard Tabletop	Video recording, tracking software
Conceptual modeling	Modeling tools (Troux, 4EM)	SmartBoard Tabletop Mobile Modeling	Video recording, software for usability testing
Model verification and analysis	Whiteboard + Modeling on paper; modeling tool + beamer or SmartBoard	Digital Pen Touch Table Mobile Modeling	Video recording, Software for usability testing
Development of operational models	Workflow-Tool (Troux, ARIS)		Software for usability testing
Model maintenance and evolution	Workflow Tool + Software development environment	Digital Pen Mobile Modeling	Software for usability testing

- Two 56″ multi-touch tables (Tacton and 3M)
- Plastic wall, whiteboards and smartboard for participatory modeling
- Enterprise modeling environments (Troux Architect, 4EM, Sparx)
- Cameras and microphones for video and audio recording in the room
- Software MaxQDA for qualitative content analysis and TechSmith Morae for usability/tracking analysis

Table 2 summarizes the equipment and supported modeling phases in the room.

5 Summary and Future Work

The paper investigated the background for conducting an experiment that compares the use of plastic walls and multi-touch tables during participatory modeling. Based on theoretical background, we derived an experimental design, which was presented in large parts. The actual experiments still have to be performed which is planned for autumn 2016.

Our long-term objective is to develop a theory of collaborative modeling with multi-touch tables. This will require a larger number of experiments, where factors possibly affecting collaborative modeling will be systematically manipulated similar to the procedure in grounded theory using theoretical sampling [7]. We are especially interested in how group members' contributions can be made visible for others and how this will influence motivation.

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References

1. Bales, R.F.: Interaction Process Analysis: A Method for the Study of a Small Group. The University of Chicago Press, Chicago (1950)
2. Basheri, M.: Multi-touch table for enhancing collaboration during software Design. Ph.D. thesis, Durham University (2013)
3. Basheri, M., Burd, L.: Exploring the significance of multi-touch tables in enhancing collaborative software design using UML. In: Frontiers in Education Conference (FIE), pp. 1–5 (2012)
4. Buisine, S., Besacier, G., Aoussat, A., Vernier, F.: How do interactive tabletop systems influence collaboration? Comput. Hum. Behav. **28**(1), 49–59 (2012)
5. Basheri, M., Burd, L.: Baghaei, N.: Collaborative software design using multi-touch tables. In: Engineering Education (ICEED), pp. 1–5, December 2012
6. Basheri, M., Burd, L., Baghaei, N.: A multi-touch interface for enhancing collaborative UML diagramming. In: Proceedings of the 24th Australian Computer-Human Interaction Conference (OzCHI 2012), pp. 30–33. ACM, New York (2012)

7. Bortz, J., Döring, N.: Forschungsmethoden und Evaluation - für Human- und Sozialwissenschaftler: Limitierte Sonderausgabe. Wiesbaden 4. überarb. Aufl. Springer, Heidelberg (2006)
8. Bachl, S., Tomitsch, M., Kappel, K., Grechenig, T.: The effects of personal displays and transfer techniques on collaboration strategies in multi-touch based multi-display environments. In: Campos, P., Graham, N., Jorge, J., Nunes, N., Palanque, P., Winckler, M. (eds.) INTERACT 2011. LNCS, vol. 6948, pp. 373–390. Springer, Heidelberg (2011). doi:10.1007/978-3-642-23765-2_26
9. Dourish, P., Bellotti, V.: Awareness and coordination in shared workspaces. In: Proceedings of the 1992 ACM Conference on Computer- supported Cooperative Work (CSCW 1992), pp. 107–114. ACM, New York (1992)
10. Drewes, S., Schultze, S., Schulz-Hardt, S.: Sozialpsychologie – Interaktion und Gruppe, Kap. Leistung in Gruppen, pp. 221–244. Hogrefe Verlag, Göttingen (2011)
11. Isenberg, P., Fisher, D.: Collaborative brushing and linking for co-located visual analytics of document collections. Comput. Graph. Forum **28**(3), 1031–1038 (2009)
12. Isenberg, P.; Fisher, D.; Morris, M.R.; Inkpen, K.; Czerwinski, M.: An exploratory study of co-located collaborative visual analytics around a tabletop display. In: Visual Analytics Science and Technology (VAST), pp. 179–186 (2010)
13. Jonas, K., Stroebe, W., Hewstone, M.: Sozialpsychologie. Springer-Lehrbuch. Springer, Heidelberg (2014)
14. Kerr, N.L., Messé, L.A., Park, E.S., Sambolec, E.J.: Identifiability, performance feedback and the Köhler effect. Group Process. Intergroup Relations **8**(4), 375–390 (2005)
15. Karau, S.J., Williams, K.D.: Social loafing: a meta-analytic review and theoretical integration. J. Pers. Soc. Psychol. **65**(4), 681–706 (1993)
16. Laufs, U., Ruff, C.: Aufbau von Multi-Touch-Systemen: Multi-Touch. In: Schlegel, T. (Hrsg.) Multi-Touch. Xpert.press, pp. 145–152. Springer, Heidelberg (2013)
17. Lundstrom, C., Rydell, T., Forsell, C., Persson, A., Ynnerman, A.: Multitouch table system for medical visualization: application to orthopedic surgery planning. IEEE Trans. Vis. Comput. Graph. **17**(12), 1775–1784 (2011)
18. Lamm, H., Trommsdorff, G.: Group versus individual performance on tasks requiring ideational proficiency (brainstorming): A review. Eur. J. Soc. Psychol. **3**(4), 361–388 (1973)
19. Maquil, V.; Psik, T.; Wagner, I.; Wagner, M.: Expressive interactions - supporting collaboration in urban design. In: Proceedings of the 2007 International ACM Conference on Supporting Group Work (GROUP 2007), pp. 69–78. ACM, New York (2007)
20. Nerdinger, F.W.: Grundlagen des Verhaltens in Organisationen. Organisation und Führung, Kohlhammer (2012)
21. Osborn, A.F.: Applied Imagination; Principles and Procedures of Creative Problem-Solving. Scribner, New York (1963)
22. Piper, A.M., Hollan, J.D.: Tabletop displays for small group study: affordances of paper and digital materials. In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI 2009), pp. 1227–1236. ACM, New York (2009)
23. Ryall, K., Forlines, C., Shen, C., Ringel Morris, M.: Exploring the effects of group size and table size on interactions with tabletop shared-display groupware. In: Proceedings of the 2004 ACM Conference on Computer Supported Cooperative Work (CSCW 2004), pp. 284–293. ACM, New York (2004)
24. Rogers, Y., Lim, Y., Hazlewood, W.R., Marshall, P.: Equal opportunities: do shareable interfaces promote more group participation than single user displays? Hum. Comput. Interact. **24**(1–2), 79–116 (2009)
25. Sader, M.: Psychologie der Gruppe. Grundlagentexte Psychologie. Juventa-Verlag (1991)

26. Schmitt, L., Buisine, S., Chaboissier, J., Aoussat, A., Vernier, F.: Dynamic tabletop interfaces for increasing creativity. Comput. Hum. Behav. **28**(5), 1892–1901 (2012)
27. Scott, S.D., Carpendale, S.: Theory of tabletop territoriality. In: Müller-Tomfelde, C. (ed.) Tabletops - Horizontal Interactive Displays. Human-Computer Interaction Series, pp. 357–385. Springer, London (2010)
28. Stirna, J., Persson, A., Sandkuhl, K.: Participative enterprise modeling: experiences and recommendations. In: Krogstie, J., Opdahl, A., Sindre, G. (eds.) CAiSE 2007. LNCS, vol. 4495, pp. 546–560. Springer, Heidelberg (2007). doi:10.1007/978-3-540-72988-4_38
29. Steiner, I.D.: Models for inferring relationships between group size and potential group productivity. Behav. Sci. **11**(4), 273–283 (1966)
30. Sandkuhl, K., Stirna, J., Persson, A., Wißotzki, M.: Enterprise Modeling: Tackling Business Challenges with the 4EM Method. Xpert.press. Springer, Heidelberg (2014)
31. Tang, A., Tory, M., Po, B., Neumann, P., Carpendale, S.: Collaborative coupling over tabletop displays. In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI 2006), pp. 1181–1190. ACM, New York (2006)
32. von Rosenstiel, L., Nerdinger, F.W.: Grundlagen der Organisationspsychologie: Basiswissen und Anwendungshinweise. Schäffer-Poeschel (2011)