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THE APPLICATION OF CREATIVITY METHODS IN VIRTUAL TEAMS IN PRODUCT DEVELOPMENT

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1. Introduction and motivation

Globalisation led to an increasing amount of production processes being internationally cross-linked. Based on this we've been observing a growing number of companies which not only organise their production sites and supply chains in global networks but also internationalise their product development process. This change was enabled by the ongoing success of information and communication technologies. Compared to the intuitive and playful exposure of so-called digital natives who combine functionalities of different online collaboration and data exchange tools (e.g. Skype and Dropbox) to organise and coordinate student projects exchange programms or their private environment companies struggle much more when it comes to the implementation of those technologies into virtual teams in product development. Looking at tasks performed by a typical product development team one can differentiate between activies which are dominated by analysis and those dominated by synthesis. Because analysis activies which are based mostly on the discussion of existing entities like product or process modells, drawings, tables or collections of ideas they can in principle be performed in a satisfying manner in virtual teams if they are supported by a suitable conferencing tool even if there still arise problems concerning for example moderation or social interaction. Compared to that synthesis activities whose aim it is to generate the mentioned entities and which therefore rely to a varying degree on creativity suffer much more from this surrounding. Thus, the need for supporting synthesis activities with a high degree of creativity like for example in idea generation activities is high. One promising way is the use of creativity methods in virtual teams which however have to be adapted to their application in virtual surroundings. This paper addresses the question how existing creativity methods often used in product development could be adapted and integrated into virtual settings to support idea generation for locally distributed teams. To reach this objective a qualitative laboratory study with 16 participants was conducted focussing on the two creativity methods brainstorming and gallery method. Both methods were implemented into three alternative software environments each based on a different working principle to deduce preferably general recommendations concerning the implementation of creativity methods into virtual teams in product development.

2. State of the art

2.1 Virtual teams in product development

Virtual teams can be understood as "a group of people who work interdependently with a shared purpose across space, time and organization boundaries using technology" [Lipnack and Stamps 1997].

Organisational boundaries can be those between different organisations (e.g. to suppliers or customers) or within different departments of a company. Advantages of virtual teams lie in strategic aspects while the biggest challenges arise from psychological and social factors like motivation and commitment [Hertel 2007].
The degree of virtuality of a virtual team may vary starting form team members having their office next door or on another floor in the same building. But in most cases a team is called virtual if not all team members often interact with each other in physical space [Sulzbacher 2003]. There exist interesting approaches which show that the advantages of collaborative work at the same place begin to vanish already at distances above 15 metres ("radius of collaborative colocation") [Lipnack and Stamps 2000]. Nevertheless the degree of virtuality in communication is seen as the most important factor defining virtual teams.

2.2 Methods in product development

In the context of product development a method can be understood as a rule-based and planned sequence of activities [Lindemann 2009]. The main objectives of using product development methods lie in generating, structuring, modelling and the evaluation of information in knowledge intensive processes [Albers et al. 2014]. There are numerous methods which support product development processes in local teams. Existing methods support different activities of product development performed by one person or a group of persons [Ehrlenspiel and Meerkamm 2013]. In product development processes the created information appears in different kinds of data types and information formates like texts, sketches, drawings, bills of material, CAD modells or physical modells which represent different degrees of concretion [Krause et al. 2001]. Most product development processes are characterised by a big number of iterations [Lohmeyer 2013] of which every iteration is supposed to increase the degree of maturity of the related documents or create new ones. Besides the creation of new methods the research about product development methods includes the adaption of existing methods to new or more specific contexts [Zier et al. 2012], the situation specific choice of methods [Albers et al. 2015], the implementation of thoses methods to the industrial practice [Albers et al. 2014b] and the evaluation of the use of methods dealing with social factors like the acceptance of methods or motivational aspects [Albers et al. 2014c].
It is very noticeable that research conducted in this context focusses almost exclusively on the development of methods for local teams which are applicated in one shared physical environment. Compared to that only few studies can be found which research product development methods e.g. in the field of creativity for virtual teams in product development. Therefore researching methods of product development for virtual teams has to rely very much on finding from different fields. Previous findings from psychologist for example show that performing brainstorming in a virtual setting ("electronc brainstorming") can even lead to advantages concerning the quantity of results, statisfaction of team members and mutual stimulation [Dennis and Valacich 1993]. But to avoid disadvantages or even reach advantages while conductiong methods of product development within virtual teams the implementation of this methods into the work environment is essential.
Though it has been shown that different data types play different roles comparing virtual and local teams. Sketches which usually support the visualization of firstly vague ideas and physical modells which by definition are not subject of virtual collaboration are of high importance for local teams whereas engineering drawings play a relatively more important role in virtual teams due to the lack of availability of commonly produced sketeches and touchable physical modells [Krause et al. 2001]. But primarily for the finding of creative solutions for functional principles and their physical implementation sketches are of high importance [Ehrlenspiel and Meerkamm 2013] and likewise one main output of creativity methods like the gallery method. Therefore one specific challenge of researching methods for virtual teams in product development is to provide suitable creativity methods which cover the possibility to include graphic information.

2.3 Brainstorming and the gallery method

Brainstorming is a wellknown method [Ophey 2005] to find alternative solutions for not too complex tasks [Wittwer 2005] in small teams. The contributions of participants usually consist of text but can be

enriched with sketches. In literature different variations of brainstorming can be found [Thiel and Wilms 2007]. They differ in the way the assessment of generated ideas is seen as part of the application of the brainstorming method itself. Appart from that brainstorming consists of four phases which are the generation of ideas, the definition of categories to cluster these ideas, the actual clustering process and a concluding discussion to prioritise ideas and eliminate dublicates. This means that a whole brainstorming process can be described as a form of primarily information generation followed by the consolidation of information. To support the effectiveness of brainstorming four rules are recommended [Pohl 2011]:

- No criticism about ideas.
- Quantity of the ideas is more important than quality.
- Unconventional ideas are explicitely welcome.
- The advancement of ideas is explicitely desired.

If conducted in local teams brainstorming underlies certain weaknesses which are mainly caused by the violation of the four rules [Schuler 2004]. To eliminate the reasons for this (e.g. social factors like hierarchy) brainstorming is sometimes conducted as "still brainstorming" or brainwriting. This means that participants write down their ideas on small cards which can be presented afterwards instead of speaking them out [Pohl 2011]. Additionally it could also be shown that conducting brainwriting in virtual teams has similar advantages compared to conventional brainstorming [Schuler 2004].
The gallery method supports the finding of solutions for challenges in construction and product design. It also consists of four phases [Albers et al. 2015]: Firstly every participant generates a first sketch for a given problem. Secondly every participant presents his sketch. This is intended to inspire the other participants. Thirdly every participant improves his first sketch or designs a new one. Afterwards all final sketches are presented, evaluated and optionally prioritised. In comparison to the brainstorming method brainwriting much more relies on sketches.

2.4 Selection of appropriate tools for synchronous communication and collaboration

One of the main task to improve collaboration within virtual teams in product development is the selection of appropriate communication and collaboration tools for specific situations [Walter et al. 2016]. Depending on the particular demand of a virtual team which can be described by actions to be performed and characteristics of the team a set of necessary and optional features can be deducted. While considering further information like available infrastructure and market prices of communication and collaboration tools comparing this set of features with a list of existing tools makes it possible to identify appropriate tools or combinations of tools. This can be performed on a strategic level for a whole company leading to a media plan for generalised use cases arrising in this company or for a operational level for a specific situation in a virtual team.

3. Need for research and research objectives

For an individual situation of synchronous communication and collaboration the approach of [Walter et al. 2016] allows for the identification of appropriate tools or combinations of tools based on the features the considered situation demands. Looking at available tools on the market shows that features are implemented in different ways. Watching sketches within a group could be done either by video conferencing or by desktop sharing after scanning the sketches or creating them with software, for example. Hence the question arises, to which extent the kind of implementation affects the suitability of an indiviual tool for a certain situation. If the way of implemtation turns out to have a great influence it will furthermore be important to know which aspects are characteristic for a good implementation and what method can be used to investigate and determine those aspects. Finally, beyond the implementation of individual features, examining essential influencing factors and deducing preferably general recommendations for transferring team-based methods of product development to virtuality is an objective for this contribution.

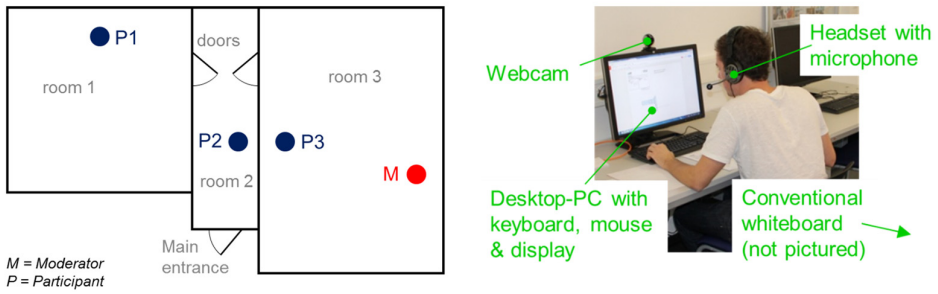
4. Research methodology

4.1 Basic concept of the laboratory study

As little research had been done on the research objectives described in the previous section the first approach to deal with these objectives had to be a qualitative one. The aim was to obtain further clues and information on the mentioned aspects instead of proving assumed hyptohesis by quantitative research. To guarantee a preferably realistic environment which is at least similar to those of virtual teams in product development with a decent number of participants and to control boundary conditions a laboratory study was chosen as research method. Thereby disturbing influences could be reduced, too. According to the research objectives already existing tool should be used. Two methods were chosen for the study: brainstorming because of its prominence and the galery method as it contains the use of sketches which is a typical characteristic for the product development context. Both methods were planned to be performed by three groups each consisting of three participants and one moderator using three different tools and combinations of tools, respectively. In two groups scheduled for the gallery method one participant cancelled at short notice so that those two groups had to execute the tasks with only two persons and the moderator. For each group the study was planned to last approx. 3.5 hours, details of the schedule are described in section 4.5. Attendees were assistants of the Insitute of Product Engineering and students of mechanical engineering at the Karlsruher Institute of Technology (KIT) interested and, in varying degrees, familiar with product development methods, e.g. due to having participated the lecture "integrated product development" at the IPEK - Institute of Product Engineering at the KIT.

4.2 Setting

For the study three rooms next to each other, but seperated by doors, were used. Each participant was placed in one of the rooms and the moderator was located together with one of the participants in the largest room. While conducting the study the doors were closed to simulate a geographically distributed environment. It was still possible for the moderator to control the procedure and assist in case of serious technical problems. Only standard equipment was used consisting of a standard desktop-PC with a screen, a keyboard, a mouse, a webcam, a headset with microphone and a conventional whiteboard.



a) b)

Figure 1. a) Schematic layout of the rooms used for the laboratory study, b) Equipment for participants

4.3 Tools used for synchronous communication and collaboration

The tools used for implementation of the methods were selected based on the main activities which are part of the methods brainstorming and gallery method. For brainstorming creating, collecting and sorting ideas in the form of text and audio-based conversation were analysed to be essential. In all cases conversation via audio was provided by voice over IP (VoIP) using a trial account of the web-conferencing-tool Adobe Connect. Certain features like a chat or moderation features were also included. Creating, collecting and sorting ideas was realised in three different ways (see Figure 2):

- In the mindmapping tool Mindmeister. It allows web-based mindmapping enabling formulation of ideas by extending already existing items as well as creating them without any connection first and sort them later on.
- In the shared whiteboard coming along with Adobe Connect. In this tool text-items can be created, edited later (text, colour, size etc.) and shifted for the final clustering.
- In the tool Meetingsphere. Brainstorming by Meetinsphere starts with the creation of a list with text items regarding a specific topic. The items can be commented and are, after defining appropriate categories, sorted into those categories.

Whereas in the brainstorming session with Meetingsphere and the shared whiteboard of Adobe Connect items were created and sorted in two subsequent steps the mindmapping approach with Mindmeister included doing both steps simultaneously to a certain extent although the positioning of items on the shared whiteboard allowed some form of clustering by creating an item at a certain position.

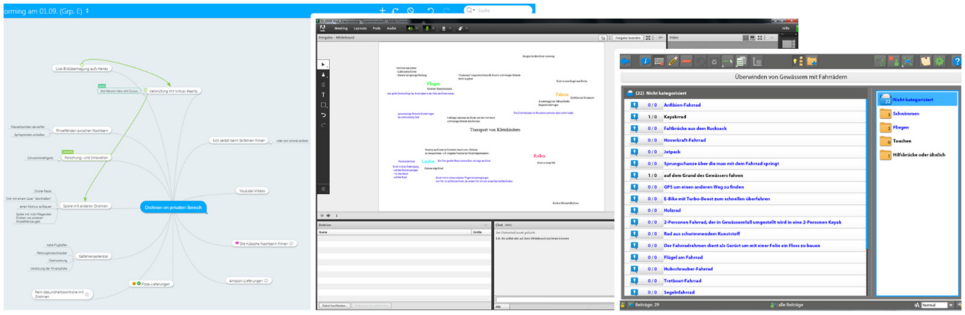


Figure 2. Overviews of tools used for brainstorming; from left to right: Mindmapping with Mindmeister, Adobe Connect with shared whiteboard and creating a list of items in Meetingsphere

The main activities in the gallery method were identified as creating sketches, viewing them within the group and conversation via audio. Therefore the following implementations were chosen:

- Adobe Connect to establish a web-based videoconference. The participants drew their sketches on conventional whiteboards which then were filmed with conventional webcams.
- Desktop-sharing and VoiP features included in Adobe Connect. Sketches were created using suitable features of Google Drive, a browser-based drawing tool similar to well-known office programs.
- In the third case a demo-version of the tool Protosphere was used. Similar to computer games Protosphere provides a virtual environment with different rooms and human looking avatars for the participants. On specific projection boards in the rooms documents can be uploaded and viewed together. The documents were also created with Google Drive. Protosphere also includes VoIP functionality.

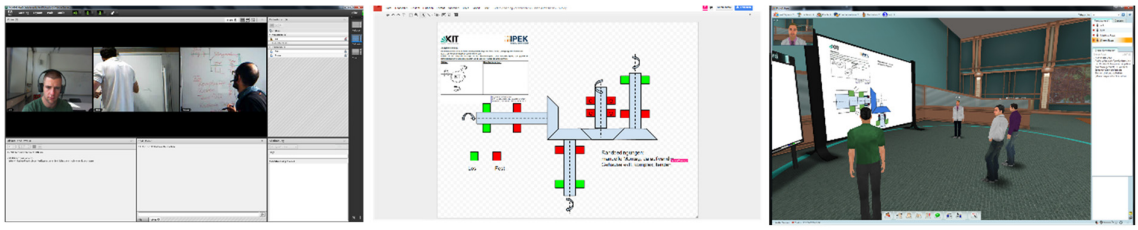


Figure 3. Tools used for the gallery method; from left to right: video-conferencing with Adobe Connect, sketching with Google Drive, presenting and discussing with Protosphere

4.4 Schedule and tasks for methods

Figure 4 shows the schedule used for each group. To minimise the influence of the order in which the tools were used the sequence of the three combinations of tools each group used was variied. The

participants were introduced to the different tools and the implementation of the methods by specifically produced tutorial videos. The tasks for performing the methods were chosen preferably realistic as well as time efficient to reduce the time investment for the participants. To reduce difficulties resulting from the tasks themselves and to focus on the handling of the tools the task were kept simple.

Approx. duration (min.)	Topics (per group)
10	Welcome
5	Initial training
50	1. combination of tools
10	Break
50	2. combination of tools
15	Break
50	3. combination of tools
20	Group discussion
Total: approx. 3,5 h	

Approx. duration (min.)	Topics
15	Introduction
25	Processing the method
10	Filling the written survey
Total: approx. 50 min	

Figure 4. Schedule for each group in the laboratory study

In the brainstorming sessions ideas for new products had to be collected meeting the following topics:

1. Crossing different types of water with bycicles
2. Possible use-cases for drones in the residential customer market
3. Transportation of small children in difficult terrain, e.g. beaches or narrow trails.

In the gallery method the participants were supposed to draw sketches showing principal solutions for functional units which realised specific requested movements, bearing concepts and transmissions. For this purpose modified versions of already existing tasks for competence assessment in engineering education were used [Breitschuh et al. 2014].

4.5 Data collection

Data was collected in the following ways. Printed surveys were used for two purposes: At the beginning of the study the participants had to answer questions regarding their educational level (no degree yet, bachelor, master, …), their knowledge about and experience with the methods they would perform afterwards and their everyday usage of media for synchronous communiction and collaboration. Those informations were collected primarily to enable investigations regarding possible dependencies between participants characteristics and other results. After each performance of the method the participants filled in another survey evaluating the used tool or combination of tools. They could rate different features of the tools, note which missing features they would have liked additionaly and highlight advantages and disadvantages of the tools from their point of view. In the end a group discussion of about 20 minutes was conducted giving the participant the opportunity to compare all tools they had used and to debate essential issues in more detail. In preparation for the group discussion a guideline was made, already filled surveys analysed and important aspects noted. For documentation all discussions were recorded. Additionally the screens, speaker's and microphone's sounds of the participants were recorded by using the tool ActivePresenter while the participants worked on the tasks.

5. Results

5.1 General findings

The impact on the results is judged to be limited though as synchronous interaction in gallery method only appears in the process of discussion and is thus assumed to be not as crucial as for collecting ideas in brainstorming.

Concerning the usage and handling of tools certain aspects were mentioned by the participants of both methods. Using different tools to provide all required functions and hence having multiple program windows was usually difficult at least when using only one screen. A major problem in that case is that features which are employed simultaneously, e.g. mindmapping with the Mindmeister tool and conversation via a separate chat tool, are not visible at the same time. Easy, intuitive handling and clarity of the user interface are found to be essential and even short blackouts are very dissatisfying for the users. Still difficult is appropriate moderation of group discussion in collaboration processes, especially assertiveness of the moderator without acting strictly, e.g. by muting a participant's microphone. Conversation via VoIP was mainly unproblematic. For the participants themselves the possibility to mute their own microphone in periods without discussion was helpful.

5.2 Implementation of brainstorming

According to established best practices participants occasionally would have liked additional thematic input when the flow of ideas dropped. Although the participants were expected to create text items and the tasks were designed accordingly the participants often missed the possibility to amend their contributions with small sketches for further explanation. For creating items the support of formulating ideas associated with already existing ideas turned out to be essential. On the one hand this can be done by providing the possibility of adding comments to existing items. On the other hand it can be implemented by features which enable connecting (independent) new ideas with one or more previously created items, e.g. in form of a mindmap. In the latter case it is important that those links are retained during the final sorting. Maintaining the process of sorting ideas accordingly is a essential characteristic of tools for brainstorming and is e.g. not provided by the shared whiteboard used for this study. If possible, the different levels of a structure in which the ideas are arranged should be visible at the same time. For this purpose two-dimensional representations like a mindmap or a shared whiteboard seem to be more overseeable compared to one-dimensional structures such as a list of text items (cp. Meetingsphere). However one-dimensional configurations facilitate the important feature of chronological traceability. Inserting of new ideas should be as easy as possible to prevent negative impact on creativity and spontaneity. Additional value can probably be created by the possibility of including pictures or web-links. Sometimes participants asked for the option to edit contributions of other group members. This function is available in some tools but was not used due to the potential for conflicts presumably coming along with it. Important issues of awareness referred to the authorship of items, pointing out newly added items and highlighting actions carried out by the moderator. Table 1 summarizes strengths and weaknesses of the tools used for brainstorming.

Table 1. Strenghts and weaknesses of tools used for brainstorming

	Tools used for brainstorming		
	Mindmapping with Mindmeister and VoIP with Adobe Connect	**Shared Whiteboard and VoIP with Adobe Connect**	**Brainstorming with Meetingsphere and VoIP with Adobe Connect**
Strengths	• Two-dimensional structuring • Features enabling linking and extending ideas • Awareness: Flashing of newly created items • Options for editing items	• Possibility of two-dimensional structuring • Available options for editing text items (e.g. colours, shifting items) • Clarity of user interface	• Clarity of user interface and categorisation • Possibility to comment existing ideas • Easy and spontaneous prompting of new ideas • Chronological traceability
Weaknesses	• Little features for moderation • No chat included • VoIP in separate program window • Retaining links during final categorization • Not always running stable	• Awareness: Who is writing which item? • No support for categorising or linking different items • Missing chronological traceability • Whiteboard not extendable	• Only one-dimensional list of items • Items and comments on items not visible simultaneously • VoIP in separate program window
Remarkable	• Extent of features supporting linking of ideas	• In this variant all features in one program window	• Possibility to "synchronise" participants to moderators perspective (e.g. for definition of categories to sort items)

5.3 Implementation of gallery method

It could be observed that using video conferencing instead of only VoIP not necessarily results in more efficient communication and collaboration. The yielding benefit in the variant with video conferencing is mostly improved awareness. But especially to transfer facial expressions the quality of the camera has to be sufficient. In this context filming the participants and their conventional whiteboard with the same camera was problematic. Viewing the sketches while presenting and discussing them within the group was deemed to be worst when using video conferencing. Looking at sketches created with Google Drive via desktop sharing or by using the virtual environment of Protosphere worked well. Important support for presenting and discussing the sketches was the ability to make annotations, i.e. non-permanent lines and comments on the currently displayed sketch. Such features facilitated comments or questions on specific and accordingly marked parts of sketches for the participants especially when discussing not their own sketch but a sketch of another group member. The fact that annotations were not available when using the video-conference feature was pointed out to be a disadvantage. Some participants would have liked the option to save annotations from the first discussion phase for the following second phase of editing. Creating sketches by using software and standard interface devices like keyboard and mouse was not as intuitive as drawing on a conventional whiteboard but it revealed some potential advantages. In that way sketches can be edited and expanded much more easily. Introducing libraries with often used standard elements could speed up the process of sketching and electronic documentation and reusability could be improved. As one way how to improve intuitive creating of sketches with computers the use of pen tablets was often suggested by the participants. In the gallery method awareness refers among others to the knowledge about who made certain annotations. Defining a specific colour for each participant could be an option in this case. The sense of belonging to a group was best when using video and worst in the variant with desktop sharing and conversation via VoIP only. Even if the avatars in the virtual environment of Protosphere can only display gestures and are not able to show facial expressions they had a positive impact on the awareness of the participants at least within the laboratory study. Table 2 gives an overview of strenghts and weaknesses of the different tool combinations as they were mentioned by the participants.

Table 2. Strenghts and weaknesses of tools used for gallery method

	Tools used for gallery method		
	Videoconferencing with Adobe Connect and conventional whiteboards	**Desktop sharing with Adobe Connect, sketching with Google Drive**	**Protosphere and sketching with Google Drive**
Strengths	• Awareness • Intuitive sketching on whiteboard	• Expandability and editability of sketches • Using annotations	• Awareness • Advantages of software-based sketching (c.f. column to the left)
Weaknesses	• Using same camera for different purposes • No annotations possible	• Awareness, other participants not visible • Using different tools	• Annotations possible, but little options • Was not always running stable • No facial impressions of avatars
Remarkable	• In total the case that was evaluated worst	• Potential advantages of software-based sketching	• Impact of virtual environment and avatars on awareness • Gestures of avatars and laserpointer

6. Discussion and outlook

6.1 Methods and usage of tools for synchronous communication and collaboration

An essential finding particularly illustrated by the example of the gallery method is the fact that transferring important methods of product development into virtuality probably needs more than just the imitation of local team workshops. Requests to see all created items in a brainstorming simultaneously categorised in a certain structure, and such ones for claritiy of the user interface at the same time illustrate that resulting requirements may lead to conflicts of objectives. Solutions may be provided by specific tools or adjustment of available ressources, e.g. more or bigger screens. The benefit of partially merging

the phases of collecting and clustering ideas also shows that modifications of present procedures may be suitable. The results of the gallery method concerning the sketches raise different questions. While potential advantages of digital sketches were indicated in principle it has to be remarked that the sketches addressed issues of mechanical design and therefore were rather definite. Sketches used to develop solution principles for a given product profile may be more abstract and thus the value of libraries with standard elements might be limited in such cases. In addition statements refering to pen tablets for more intuitive sketching and the issue of display size mentioned above suggest further research concerning the potential benefit of additional interface devices for processes of synchronous communication and collaboration in product development.

6.2 Research method

Principally the described attempt to evaluate and improve implementations of methods in virtual product development teams seems to be suitable. A priori the validity of results from laboratory studies for real product development settings is uncertain. This issue may be objective to further research. Nonetheless it is estimated that the presented research method is an efficient way to obtain hints on important aspects for methods of integrated product development in virtuality. Future research could also address characteristics and influence of the group of participants, e.g. the familiarity of the attendees with each other or different specialisations. Such aspects were not covered within the presented study. Another factor that could not be analysed due to the short time in which the participants were introduced to each tool is the effect of routine in handling the tools.
Brainstorming and gallery method are only two examples out of a great number of creativity methods and creativity methods themselves are only one part in the wide range of important methods for product development. The application of other methods in virtual teams in product development should also be subject of investigation. Formulating a general approach which enables presumptions regarding appropriate design of methods for virtual development teams will be an important issue helping to reduce the necessary effort for analysing and testing single methods. Finally such theoretical concepts as well as results of qualitative research is to be validated by quantitative studies in real product development environments in companies.

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References

Activepresenter, Available at <https://atomisystems.com/activepresenter>, [Accessed 07.12.2015].

Adobe Connect, Available at <http://www.adobe.com/de/products/adobeconnect.html>, [Accessed 07.12.2015].

Albers, A., Lüdcke, R., Bursac, N., Reiß, N., "Connecting knowledge-management-systems to improve a continous flow of knowledge in engineering design", Proceedings of TMCE 2014, Horváth, I., Rusák, Z. (Eds.), Budapest, 2014a, pp. 393-402.

Albers, A., Reiß, N., Bursac, N., Urbanec, J., Lüdcke, R., "Situation-appropriate method selection in product development process – empirical study of method application", Proceedings of NordDesign, 2014c, pp. 550-559.

Albers, A., Reiß, N., Bursac, N., Walter, B., Gladysz, B., "InnoFox – Situationsspezifische Methodenempfehlung im Produktentstehungsprozess", Stuttgarter Symposium für Produktentwicklung, 2015.

Albers, A., Youa, Y., Klingler, S., Behrendt M., Zhang T., Song K., "Supporting globally distributed product development with a new validation concept", 24th CIRP Design Conference, 2014b.

Breitschuh, J., Mattes, P., Albers, A., "Effiziente Kompetenzdiagnostik in der Maschinenkonstruktionslehre – Das Zeichnerische Problemlösungs-Inventar", Wie viel (Grundlagen)Wissen braucht technische Bildung? Wege zu technischer Bildung, Kammasch, G., Dreher, R. (Eds.), Siegen, pp. 64-71.

Daft, R., Lengel, R., "Organizational Information Requirements, Media Richness and Structural Design", Management Science, Vol.32, No.5, 1986, pp. 554-571.

Dennis, A., Valacich, J., "Computer Brainstorms: More Heads Are Better Than One", Journal of Applied Psychology, Vol.78, No.4, 1993, pp 531-537.

Dennis, A., Valacich, J., "Rethinking Media Richness: Towards a Theory of Media Synchronicity", Proceedings of the 32nd Hawaii International Conference on System Sciences, 1999.

Ehrlenspiel, K., Meerkamm, H., "Integrierte Produktentwicklung - Denkabläufe, Methodeneinsatz, Zusammenarbeit", Carl Hanser Verlag München, 2013.

Google Drive, Available at <https://www.google.com/intl/de_de/drive>, [Accessed 07.12.2015].

Hertel, G., "Handbuch der Arbeits- und Organisationspsychologie", Schuler, H., Sonntag, K. (Eds.), Hogrefe Verlag GmbH & Co. KG Göttingen, 2007.

Krause, F., Tang, T., Ahle, U., "Leitprojekt integrierte Virtuelle Produktentstehung - Fortschrittsbericht April 2001", Fraunhofer-IRB-Verlag Stuttgart, 2001.

Lindemann, U., "Methodische Entwicklung Technischer Produkte: Methoden Flexibel und Situationsgerecht Anwenden", Springer Berlin, 2009.

Lipnack, J., Stamps, J., "Virtual teams: People Working Across Boundaries with Technology", John Wiley & Sons New York, 2000.

Lipnack, J., Stamps, J., "Virtuelle Teams: Projekte ohne Grenzen; Teambildung, virtuelle Orte, intelligentes Arbeiten, Vertrauen in Teams", Wirtschaftsverlag Carl Ueberreuter Wien, Frankfurt, 1997.

Lohmeyer, Q., "Menschzentrierte Modellierung von Produktentstehungssystemen unter besonderer Berücksichtigung der Synthese und Analyse dynamischer Zielsysteme", Institute of product engineering Karlsruhe, 2013.

Meetingsphere, Available at <https://www.meetingsphere.com>, [Accessed 07.12.2015].

Mindmeister, Available at <https://www.mindmeister.com/de>, [Accessed 07.12.2015].

Ophey, L., "Entwicklungsmanagement: Methoden der Produktentwicklung", Springer Berlin, 2005.

Pohl, M., "Kreativitätstrainings und kreative Kompetenz: Durchkonzipiertes Trainingsdesign", Cornelsen Berlin, 2011.

Protosphere, Available at <http://protonmedia.com>, [Accessed 07.12.2015].

Schuler, H., "Gruppe und Organisation", Hogrefe Göttingen, 2004.

Sulzbacher, M., "Virtuelle Teams", Tectum Verlag Marburg, 2003.

Thiel, M., Wilms, F., "Unternehmensführung: Eine ganzheitliche Managementlehre", Haupt-Verlag Bern, Stuttgart, Wien, 2007.

Walter, B., Rapp, S., Albers, A., "Selecting appropriate tools for synchronous communication and collaboration in locally distributed product development", proceedings of NordDesign 2016 [abstract accepted].

Wittwer, W., "Methoden der Ausbildung: Didaktische Werkzeuge für Ausbilder", Christiani Konstanz, 2005.

Zier, S., Reiß, N., Birkhofer, H., Bohn, A., "Investigating Elementary Design Methods - Using pattern recognition methods to define method modules", NordDesign, 2012.

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