

Supporting distributed design teams with regard to processes, methods & tools and competencies & qualifications

Ann-Kathrin Bavendiek¹, Hilko Paulsen², Thomas Vietor¹, Simone Kauffeld²

¹ *Institute for Engineering Design, Technische Universität Braunschweig*
a-k.bavendiek@tu-braunschweig.de
t.vietor@tu-braunschweig.de

² *Institute of Psychology, Technische Universität Braunschweig*
h.paulsen@tu-braunschweig.de
s.kauffeld@tu-braunschweig.de

Abstract

Due to globalization, increasing concurrence, time pressure, as well as the complexity of today's products, enterprises develop and produce products more internationally. This results in the collaboration of persons from different locations and often from different disciplines like mechanics, electronics and software. Besides the diverse disciplines, diverse cultures may be involved in international collaborations. Enabled by the increasing digitalization, this leads to potentials like the collaboration of experts from all over the world or the proximity to customers at local markets. However, the collaborators have to face additional challenges of teamwork compared to traditional face-to-face teams. Some of the challenges are coping with a virtual working environment, lacking informal communication due to distribution and higher demands for flexibility. Hence, additional competencies are required to deal with these challenges.

As there are many approaches to describe or support collaborative design on different layers, this paper organizes previous research into the three layers 1) process, 2) methods & tools and 3) competencies & qualification. The consideration of existing support tools and approaches helps to identify current gaps in the wide field of collaborations. Additionally, an exemplary situation in a digital working scenario of an enterprise is used to identify further needs. Based on these findings, this contribution presents the concept for a tool, called KAMiiSo tool, supporting collaborative engineering design teams on the three defined layers. This tool focusses on the provision of assisting methods (e.g. brainwriting, FMEA, etc.) in combination with tools (e.g. e-mail, video-conferencing, etc.) that are bound to previously defined processes within a process generator. The third layer is considered among the boundary conditions of the methods and tools described via team-oriented attributes. Additionally, a reflection tool is part of the superordinate KAMiiSo tool that helps reflecting actions within the collaborative design situations. The concept was presented to experts from the enterprise used to define the digital working scenario and from other enterprises to gain feedback. A conclusion will summarize the findings and present future work.

Keywords: collaborative design, support tool, design methods, design process, competencies

1 Introduction

Today's products are oftentimes a result of collaborations of experts from different domains like mechanics, electronics, software, design, sales, etc. In many cases, these experts are not located at one single site but at various, locally distributed sites. Due to the increasing digitalization of the working environment, cross-site cooperation and collaborations are technically supported and even possible across country borders (Dulebohn & Hoch, 2017; Kauffeld et al., 2016; Schulze & Krumm, 2017). This leads to great opportunities like market proximity, increased capacity usage, or economic advantages such as cost reductions (Gaul, 2001; Larsson et al., 2003). To gain advantages from these opportunities, corresponding challenges like cultural misunderstandings, time shifts, data exchange and missing informal communication have to be met (Dulebohn & Hoch, 2017; Gilson et al., 2014; Schulze & Krumm, 2017). As a consequence, distributed, virtual teamwork is requiring a broad set of competencies from team members (Hertel et al., 2006; Kauffeld et al., 2016; Schulze & Krumm, 2017).

In this contribution, collaborative design is not only limited to locally distributed design tasks. Collaborations are seen as teams that communicate, coordinate and collaborate to fulfill a common goal defined by the design task. Besides different sites, the involvement of diverse disciplines is possible. Even local teams mainly communicating and collaborating virtually can be included in the definition of a collaborative design team. The contribution refers to the term of the "degree of virtuality" of a team. This means that a higher degree correlates with more virtual communication, coordination and collaboration within the team, e.g. (Krumm et al., 2016; Schulze & Krumm, 2017). Thereby, this contribution considers the three layers 1) process, 2) methods & tools, and 3) competencies & qualification (Bavendiek et al., 2017) which will be used in section 2 to organize existing research work.

1.1 Phenomenon and problem clarification

To motivate the research work and to clarify the problem, this research project is based on an exemplary situation of a digital collaboration scenario which will be presented in this section. The scenario is based on a collaboration within one of the associated industry partners and its group of companies. It is transferable to other enterprises and scenarios as it is a generic situation. The exemplary group of companies consists of multiple enterprises located on different continents, being Europe (multiple sites in Germany and Slovakia) and Asia (China and India). The products which are developed and produced locally but also across the sites are grabs and other solutions for the lifting and handling of goods. Since many customers are situated in Asia, sites in China and, later on, in India were established. First, the sites only produced the grabs. Nowadays, both sites hold their own small design department. This allows the development and adaption of current solutions to local markets and circumstances. However, the diversity of product ideas and individual solutions disperses. As there is no cross-site exchange, an overview of the complete product and solution portfolio is missing. The addressed scenario aims at the creation of a cross-site idea management. This comprises the central storage of ideas, solutions and product data on the one hand, and the collaboration on new development task to achieve synergies from the various expertise and know-how on the other hand. The aim of this research project is not to provide a corresponding software tool that allows sharing the data. In fact, existing solutions for data exchange will be considered and used. The contribution follows the objective to assist the designers across the sites to collaborate in such digital collaboration scenarios as described exemplarily. Thereby, adequate digital collaboration processes are defined, suitable methods and tools are proposed and required

competencies and possible training measurements are highlighted. All these supportive elements will be combined in a software tool in future work. Thus, the aim of this contribution is to describe the tool concept and its application.

To better understand the exemplary collaboration scenario and the resulting requirements on a supportive tool, the involved designers, sales men and technicians from production were interviewed within guided individual interviews (N=13) and brought together in two process defining workshops (Paulsen et al., 2018). The interviews revealed information on the current situation as well as proposals for a potential digital collaboration scenario. The need to describe and structure the process and to provide assisting engineering methods and tools was one of the major findings for a supportive tool. The provision of reflection on possible actions, e.g. for learning new software, was also found to be important for a continuous improvement of the collaboration process. To prepare the persons involved for intercultural collaborations, different training aspects were mentioned to be relevant. Besides language skills and intercultural training, the handling of technologies used seemed to be improvable. Thus, the need to define required competencies for single activities in the process was stated.

1.2 Research approach

To address the above revealed requirements on a supportive tool for digital collaboration scenarios, two main research questions were formulated. The first question aims at the identification of existing work that can be the basis for a further development: *“Which elements of collaborative design are already supported in which manner?”* The results of this research question will be presented as an overview on the three layers 1) process, 2) methods & tools and 3) competencies & qualification, e.g. (Bavendiek et al., 2017) in section 2. A conclusion for further development and support will be given in the last part of section 2, considering the linkage between the layers. Based on this conclusion, the second research question *“How can gaps in support of collaborative design be closed by means of a software tool?”* is addressed in section 3. The question will be answered by proposing a concept for a supportive software tool consisting of mainly three elements. Each element will be described in section 3 in detail and with regard to the exemplary digital collaboration scenario and its specific requirements. As this contribution presents a conceptual stage of a software tool, a discussion with feedback from industry partners will be given in section 4. The last section concludes the contribution.

2 Analysis of existing research work

Based on previous research (Bavendiek et al., 2017), the analysis of existing support tools for collaborations is clustered into three layers. These layers are (1) the process layer which comprises the organization and management of a collaboration, the processes and tasks to be done, (2) the methods & tools layer, describing engineering methods and tools for communication or supporting activities within the process like decision making, and (3) the competencies & qualification layer which includes the designer as a human, considering competencies and qualification. These layers strongly interact with each other. There are many interrelations between the layers that are supported by various approaches and tools. An overview of some of these approaches and tools will be described in the following section 2.1 from the perspective of engineering design research context, focusing mainly on the process and or methods & tools layer. The approach on the competencies & qualification layer will be different: It is based on needs in digital collaborations which were identified from an organizational psychology view. As most of the assisting tools are provided commercially, they are rarely accessible for research purpose. The identified needs will be described in section 2.2. Findings regarding a combination of the three layers will be presented in section 2.3 as a conclusion of the analysis results on the different layers and their interdependencies.

2.1 Engineering Design (mainly process and methods & tools layer)

As found in the expert interviews, there is a need to structure processes and assisting tools for the collaboration, meaning also for communication and coordination. One tool assisting and guiding through the design process is the InDeaTe tool proposed by Chakrabarti et al. (2017). The InDeaTe tool leads the user through the design process and suggests methods and tools that can be applied within the currently considered step. However, the proposed design process is described in a general and abstract manner to be applicable to various different design tasks. Similar approaches are followed by method collections that provide diverse descriptions of methods, mostly connected to processes via basic design activities or assignments to process phases. Examples for method collections are given by Cross (2007) or Lindemann (2009) as paper based versions, or in the form of method portals, provided by Bavendiek et al. (2016b) or SPP GmbH (2004) and as mobile application, as shared by Albers et al. (2014). The last-mentioned mobile application called InnoFox allows the user to access methods via the SPALTEN model (Albers et al., 2005), which represents single steps within a design process. Another approach to connect process steps and methods are so-called “elementary methods” approaches (Zanker, 1999; Zier et al., 2012) that describe methods based on basic elementary activities. However, all of these approaches do not primarily focus on the support of collaborations.

When bringing the collaboration into focus, research often addresses the exchange of information, knowledge and data. The field of computer-supported collaborative work (CSCW) mainly deals with these topics. An exemplary tool supporting the coordination and communication in terms of exchanging information and data is the IPPOP tool (Robin et al., 2007) based on the GRAI modelling technique (Girard & Merlo, 2003). For a better traceability of information and documents in the design process, Martinec and Pavkovic (2014) propose a visualization technique via diagrams. Further commonly used modelling techniques for representing processes or information flows are UML diagrams (Yesilbas et al., 2006), business process modelling like BPMN diagrams (Bavendiek et al., 2018), Gantt charts or other visual techniques (digital and paper-based) as they were used by industry partners in the project.

Focusing on the communication and coordination, there is a wide field of software solutions with different foci. Besides traditional media like phone, fax and postage, computer-supported media are well-established (e.g. e-mail, chat, file sharing, group-calendar etc.). An overview of the media distribution in practice is given, for instance, by Grieb and Lindemann (2005). In a more and more digitalized working environment, the offer of virtual reality (VR) tools increases like, exemplarily, the software offered by Arthur Technologies (2017). This software proposes the use of VR for workshops sharing different types of files and data in one digital room. However, the utilization of VR technologies in daily business does not seem to be very common: none of the project partners in the scenarios considered holds corresponding technologies. In fact, the use of e-mail and file sharing is seen as an adequate tool in most situations independently from the task. Face-to-face meetings are also highly appreciated, whereas mainly no need for video-conferencing is seen. A classification with advice on which media can be used for specific situations to facilitate the communication seems helpful. Such a classification is given by Gaul (2001) in the form of the House of Communication.

2.2 Organizational psychology (mainly competencies & qualification layer)

To deal with job demands, designers require competencies comprising knowledge, skills, abilities and other characteristics (KSAOs) (Campion et al., 2011; Stevens, 2013). Competencies are often described at a behavioural level and provide an operational definition of how a job can be done effectively (Campion et al., 2011; Stevens, 2013). It is important to distinguish competencies from qualifications (Kauffeld & Paulsen, 2018). Qualifications are

based on a formal learning process, following a specific curriculum and often resulting in a certificate like e.g. the qualification of carrying out quality audits. However, the learning input can vary from actual task demands. Consequently, the proof of a qualification by a certificate does not allow the conclusion that a designer has the required competencies to fulfil the job. However, qualification is often relevant for legal issues. In this context, work-integrated less formal learning is of relevance. Formal training subsequently requires a successful process of transfer (Grohmann et al., 2014; Massenberg et al., 2015; Massenberg et al., 2016). This process is influenced by the learning-transfer-system composed of individual factors (e.g. motivation), training related factors (e.g. transfer design) and work-related factors (e.g. supervisor support) (Bates et al., 2007; Holton et al., 2000). Furthermore, competencies can be directly acquired through more informal learning processes while working on tasks (e.g. by designing components with special features, e.g. Kortsch & Kauffeld, 2016).

A systematic competency development considers a broad range from formal to informal learning processes, including planning, implementing and evaluating competency development in organizations (Campion et al., 2011; Kauffeld & Paulsen, 2018; Schleidt & Eigner, 2010). It contains at least three elements: 1) collection of relevant competencies in a competency model, 2) the assessment of competencies and 3) the application of measures for competency development. Thereby, competency models systematize and structure required competencies within an organization (Campion et al., 2011; Redmond, 2013). Despite organization-specific competencies, there are also generic competencies (Soderquist et al., 2010) that are relevant across organizations. Generic competencies have been described for all jobs (e.g. Bartram, 2005) as well as specific jobs (e.g. software development, CEN, 2014). Regarding distributed teamwork, a literature review revealed six important clusters of KSAO: Media, Communication, Trust-related, Intercultural, Self-management and Conflict management KSAOs (Schulze & Krumm, 2017). Another competency model that is more specific for product development comprises entrepreneurial acting competency, communication competency, self-management competency and work-life-balance competency within the House of Engineering Competencies (Schleidt & Eigner, 2010). Both competency models have in common that they emphasize soft skills instead of hard skills. Soft skills include intrapersonal skills (e.g. ability to manage oneself) and interpersonal skills (e.g. interactions with others) whereas hard skills refer to more technical skills (e.g. working with data, software, equipment) (Laker & Powell, 2011). However, competency models are supposed to consider both hard as well as soft skills (Campion et al., 2011).

Regarding leadership in virtual teams, leadership is often shared among employees (e.g. Dulebohn & Hoch, 2017). Besides the formal supervisor team members work self-organized and lead themselves. Virtual team work compared to traditional face-to-face teams requires more leading and decision making from team members (Krumm et al., 2016). Shared leadership includes also task management (Grille et al., 2015; Grille & Kauffeld, 2015). Task management requires hard skills (as well as soft skills). For example, setting appropriate goals and monitoring goal progress is at least linked to task-related knowledge. An integrative perspective linking processes, methods and competencies seems to be helpful to consider the interaction between hard and soft skills.

2.3 Linkage of disciplines and current gaps

Some required competencies for collaborative design may be more generic (e.g. communicating clearly), while others are more task-dependent (e.g. monitoring others works). Consequently, in a product development process, competency requirements can vary within the process and its tasks. Simultaneously, competencies such as “communication competencies” are described at an abstract level without providing guidelines on how to communicate in specific situations.

To overcome this shortcoming, competencies should be described at a more specific level and with regard to the process and its activities.

Linking competencies to business processes (e.g. via the BPMN, see Bavendiek et al. (2018)), integrates competency requirements within the value creation chain. This approach can be beneficial as it aligns competencies with strategy (Paulsen et al., 2018). Besides the linkage of process and competencies & qualification layers, the linkage of the latter with methods & tools on the corresponding layer seems not sufficiently supported, yet. However, competency information help to identify suitable methods for collaborative design teams and possible tools, e.g. for communication that enable the collaboration over different locations. Thus, the linkage of methods & tools to processes, as already existing in many approaches, shall be enhanced by linkages to the competencies & qualification layer.

3 Concept for the KAMiiSo tool

Based on requirements gathered from the industry partners involved in the project (see section 1.1), a concept for a collaboration support tool called KAMiiSo tool was developed. The concept is based on existing support tools and further research results that were analyzed beforehand (see section 2). The aim of the research project is the implementation of the concept in a software tool. This section describes the basic concept for this software tool, which will be implemented in future work. The first part of this section presents the main idea of the tool. The subsequent parts give detailed descriptions of the single elements of the tool as conceptual descriptions.

3.1 Overall concept

The idea of the KAMiiSo tool is the support of collaborative design scenarios on the three layers – process, methods & tools and competencies & qualification – within one single tool. The first element of the tool is a generator for digital collaboration processes. These processes describe the underlying collaboration scenario on an abstract level using activities (see Figure 3-1, section 3.2). The defined process indicates boundary conditions to propose methods and tools that can be used (section 3.3). Furthermore, competencies especially required for the collaboration scenario and the utilization of the proposed methods and tools are identified and training possibilities are suggested. The third element of the KAMiiSo tool provides reflection on collaborative action (section 3.4). The purpose of this reflection is to develop competencies and evaluate competency development. By doing so, the employees can reflect on the quality of the process, used tools and methods applied but also on the competencies and their training measurements. The three elements can be used to adapt the support tool to individual collaboration scenarios to be applicable for the designers.

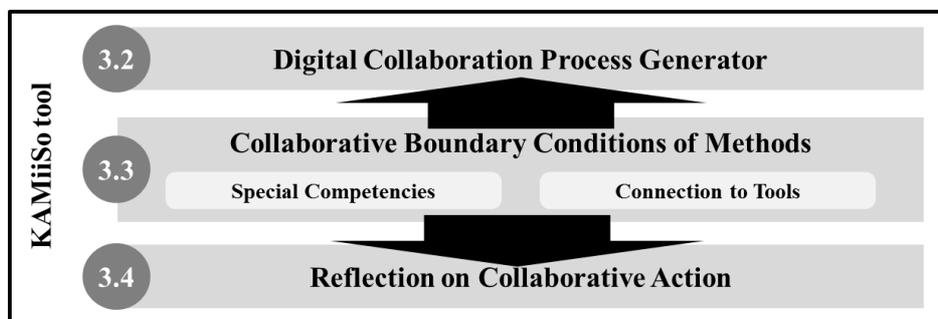


Figure 3-1 Elements of the collaboration support tool KAMiiSo

The KAMiiSo tool is conceived to support collaborative design teams during their work. It is not meant to be a tool to collaborate like video-conferencing or data exchange but to assist the

individual designer in a collaborative situation by proposing processes and activities, tools, methods and measurements for competencies training. The digital collaboration scenario as described in section 1 mirrors such an exemplary application scenario. Prior to the application in the collaboration scenario, the scenario or multiple scenarios have to be implemented via the process generator, the definition of methods, tools, competencies and possible reflective questions. In the following, each element of the conceptual tool is explained in more detail, referring to the introduction scenario of the cross-site idea management.

3.2 Defining adequate digital collaboration processes

The first element of the KAMiiSo tool is a process generator, mainly aiming at the prior definition of a scenario. It is based on the modelling of design and business processes as it can be done e.g. with BPMN. According to the modelling technique presented in Bavendiek et al. (2018), the activities of the processes are linked to methods, tools and competencies. The process generator provides a pool of basic activities on an operational level (e.g. planning, analyzing or ideation). These activities are used to generate processes within digital collaboration scenarios. Due to the connection of each activity to corresponding methods and supportive tools, a set of methods and tools can be selected from. This process generator is seen as a core element as it is adequate to describe the digital collaboration scenario via a process model. Method descriptions as well as required competencies as behavioral descriptions can be accessed via this process description.

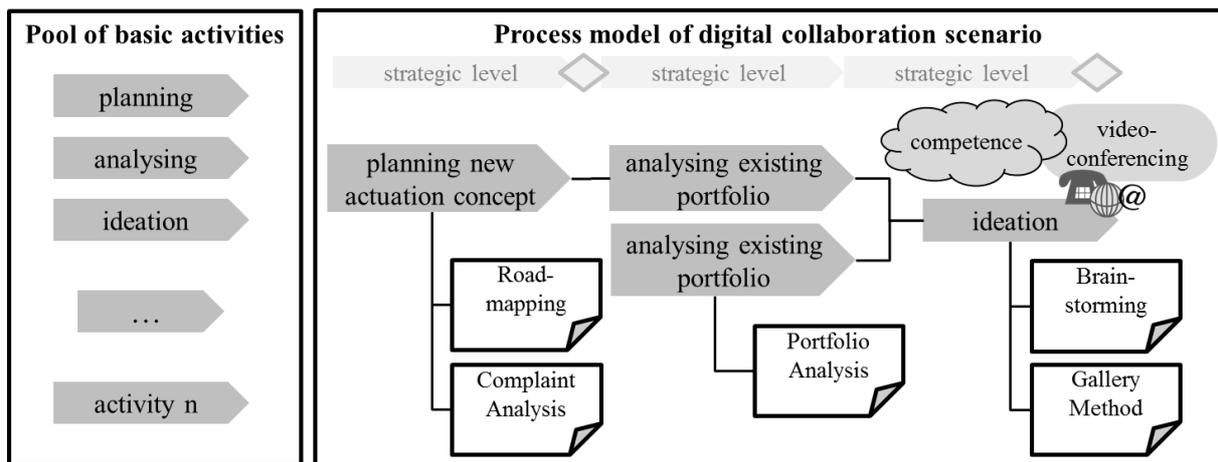


Figure 3-2 Building digital collaboration processes using the pool of activities and choosing from proposed methods and tools

A schematic representation of the main elements of this process generator is demonstrated in Figure 3-2. On the left-hand side, the pool of basic activities on an operational level is given. The box on the right-hand side contains the modelled process in the digital collaboration scenario. Methods and assisting tools for the single steps are proposed for the activities. Each activity is additionally complemented by boundary conditions. These can contain information on communication media, priority of parallel activities or involved participants.

The process shown in Figure 3-2 is the first part of the cross-site idea management of the collaboration scenario described in section 1. The initiating point is set by one site planning a new component or product. After having clarified the idea of what to develop, further sites and experts are involved in the process for the next step. In this case, it is the analysis of existing actuators in current products. The results are first searched at the single sites and, secondly, brought together for the ideation phase. The ideation phase itself is conducted with members from different sites to combine cross-site expert knowledge. Usually, video-conferencing is used as the preferred medium of communication. Furthermore, competencies seem to be

relevant, that can be defined by specific behaviors. For example, action-orientated statements are functional within meetings (e.g. signaling interest in ideas, taking on responsibility, c.f. Kauffeld and Lehmann-Willenbrock, 2012). Simple methods that are suitable for cross-site ideation are applied. Within the next element of the KAMiiSo tool it is described how to decide on which method to select and how to adapt it to the boundary conditions.

3.3 Linking collaborative boundary conditions to methods

The digital collaboration scenarios are complemented by methods and tools that support the single activities in the process. As presented in section 2, there are already many approaches and tools to support the combination of method application and processes (e.g. InnoFox or InDeaTe). The missing component for the digital collaboration scenarios is the description of relevant information on the collaboration and the team. This means that there is rarely information on how to adapt a method to a digital collaboration scenario or what additional competencies are required in a virtual design situation. Conceptually, correlations between methods, collaboration characteristics, communication technologies and competencies were elaborated and presented by Bavendiek et al. (2016a). This previous work was combined with the software concept of the method portal Methodos (Bavendiek et al., 2016b) and complemented by further functionalities to create the concept for this element of the KAMiiSo tool. Besides usual attributes for method descriptions (method name, description, procedure, method aim, etc.), team aspects and collaboration characteristics were systematically rated regarding their influence on a method application. Those aspects found out to be most influencing like the team size, the local and temporal distribution or cultural and hierarchical differences were added as describing attributes for each method in the method collection of the KAMiiSo tool. Additionally, adaptations for virtual teams in digital collaboration scenarios and hints for communication tools to be used were complemented to the method descriptions. An example of the added information in a method description is shown for the simple Brainstorming method in Figure 3-3.

Brainstorming		team size <input type="checkbox"/> 1 <input checked="" type="checkbox"/> 2-3 <input checked="" type="checkbox"/> 4-6 <input checked="" type="checkbox"/> 7+	suitability for virtual or distributed teams:
multidisciplinarity <input type="checkbox"/> homogenous <input checked="" type="checkbox"/> balanced <input checked="" type="checkbox"/> heterogeneous	competencies: professional competence: <input type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/> social competence: <input type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/> methodological competence: <input type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/> self competence: <input type="checkbox"/> <input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	local distribution <input checked="" type="checkbox"/> distrib. rooms <input checked="" type="checkbox"/> distrib. locations <input checked="" type="checkbox"/> distrib. countries	temporal distribution <input checked="" type="checkbox"/> parallel <input type="checkbox"/> sequential <input checked="" type="checkbox"/> mixed
hierarchical differences <input type="checkbox"/> possible <input checked="" type="checkbox"/> not recommended		language <input checked="" type="checkbox"/> same <input type="checkbox"/> different <input checked="" type="checkbox"/> one common	@ communication tools <ul style="list-style-type: none"> audio/ video conferencing with shared screen face-to-face meeting with presentation board mind-mapping / presentation software
culture <input checked="" type="checkbox"/> same <input checked="" type="checkbox"/> similar <input checked="" type="checkbox"/> different			
method experience 			
variants or adaptations for virtual teams: <ul style="list-style-type: none"> use audio / video conferencing with shared screen when not meeting in one room be aware of time shifts and consider them planning the session use a language everyone is able to follow and to contribute ideas sensitize the team members of cultural differences 			

suitable suitable with adaptations (see hints)

Figure 3-3 Additional information to describe methods for digital collaboration scenarios

In the cross-site idea management scenario, the Brainstorming method is applied for a first ideation process to exchange the ideas and solutions already contained in the portfolio of each site. Due to internet speed limitations, videoconferencing is reduced to audioconferencing with a shared screen that is used to illustrate the generated ideas. A moderator at the site that is leading the idea management process documents the ideas mentioned on a mind-map. This mind-map is shared on the screen to allow all participants an overview of all ideas generated so far. The final result is shared via the data exchange system of the enterprise group. Similar descriptions and adaptations for other methods were elaborated and will be available in the KAMiiSo tool in a digital version.

3.4 Providing reflection possibilities in collaborative design teams

The purpose of the reflection tool is to enhance competency development within collaboration scenarios. At the same time, the tool can be used to evaluate competency development as well as interventions (e.g. implementing new work processes, implementing a new method or communication tools). Thus, there are several use-cases for the reflection tool, especially but not only in digital collaboration scenarios. For example, a new or changed process may require new competencies. Additionally, a newcomer in a process also needs to deal with specific job demands and can use the tool to reflect on the individual learning process. Another example may be the application of a new method that supports the collaboration. To support all these situations, the reflection tool includes the following main elements:

- *Assessment*: Competencies and other relevant factors (e.g. job demands, job resources within a new process) are assessed several times over time (e.g. weekly monitoring). That is, designers get a link to a short online-questionnaire, e.g. once a week.
- *Reflection*: Opportunities for reflection are provided (e.g. by open-ended questions or short advices) based on assessments. That is, designers get short messages that help them to reflect on their behaviors and actions within the collaboration.
- *Feedback*: Feedback based on assessments including an interpretation are provided (e.g. intra and individual comparisons). That is, designers get a short report about the current state.

Implemented as a combination of a survey-feedback technique and a diary study approach, the tool enables to support designers continuously during learning processes (e.g. by providing instructions for learning tasks, provide feedback or open questions that evoke reflection). This support, in turn, should foster self-regulation, as recent research on transfer-of-training provides empirical evidence for the role of self-regulation processes in skill and knowledge application after formal trainings (Seiberling & Kauffeld, 2017). For an optimal support for the designer, the following three aspects are considered within the reflection tool:

- *Planning*: Learning tasks are assigned (e.g. challenges). That is, designers get short instructions that initiate learning processes (e.g. to choose an appropriate method)
- *Integration*: Assessment, reflection, feedback and planning are considered simultaneously in order to support designers to deal with job demands and develop their competencies.
- *Continuity*: For a defined learning process (e.g. a learning project) assessment of competencies or/and other relevant constructs, reflection, feedback and planning are repeated continuously.

Thus, the reflection tool is used to support the competencies & qualification layer of collaborations and to provide feedback options on the other layers and their proposed support.

4 Discussion

A discussion of the KAMiiSo tool concept with two different industry partners revealed first practical hints for the later tool. The process generator is perceived as very helpful but should only be used once to define a process and propose methods, tools and give information on required competencies. The defined process shall be applied in the following by the designers. Thus, the level of process definition in the beginning is an interesting and challenging point, which has to be defined in future work. Currently, the processes are only modelled on a strategic level. This level does not allow an assignment of specific methods and tools, yet. Competencies can also only be addressed on a very generic level. Thus, an operative level has to be chosen for the process generator, the assignment of methods, tools and competencies.

The additional information to describe methods using boundary conditions, competencies and tools for collaboration were seen as rather useful. Especially the combination of media (tools) with methods and underlying activities was appreciated. One of the major challenges is seen in the media-task fit within international collaborations. The conceived element for methods and tools of the KAMiiSo tool tries to assist the designer with this decision.

The reflection tool was appreciated for being used to plan and assist learning tasks, e.g. for new designers in a team or for the monitoring of the introduction of new software. For the application in industry, the social embedment of the tool within the company is relevant. Although it is interesting from a scientific point of view to gain insights on processes over time, the repetition of questions can evoke resistance to answer the repeating questions. Thus, it is important to design more varied and motivating reflective questions, e.g. using symbols for emotions instead of text.

All things considered, the KAMiiSo tool shall assist designers working in a digital collaboration scenario on the three introduced layers: Processes can be defined, methods and tools can be chosen considering the boundary conditions of the collaboration and finally, the reflection on actions within the collaboration is possible. The introduced concept has to be realized in a software tool in future work.

5 Conclusion

The contribution presents an overview of different supportive tools and research on the support of collaborative design on three layers, 1) process, 2) methods & tools and 3) competencies & qualification layer. Demands from industry and gaps in current approaches were identified by a combination of the three layers in one tool. Thus, a concept for the KAMiiSo tool supporting collaborative design was presented. The main elements of the tool are a process generator, method descriptions complemented by special information on collaborative design and a reflection tool to monitor and reflect processes within the collaboration. The elements are connected with each other via the process layer.

Generally, the concept for the KAMiiSo tool was verified by the industry partners. The relevance for the tool was seen. There were some doubts concerning the applicability for the designers in their daily work, though. A close linkage to the daily processes was estimated to make the tool even more valuable and more likely to be used. Future work has to be done to implement the concept into a software demonstrator to gain more feedback within reference projects. An evaluation of these projects will reveal detailed insights on relevance, applicability and quality of the tool.

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