

Supporting Creativity in Virtual Teams

Hilko Donker

Dresden University of Technology, Faculty of Computer Science
donker@inf.tu-dresden.de

Abstract

Distributed and widespread companies already use extensively groupware to support their work processes. A groupware support is not essential for the support of every day work but also for the work on innovations. Innovations depend on valuable ideas. These ideas do not appear by themselves. Teams have to work on them. In this paper we are going to analyze the impact of teams to work out valuable ideas. We are going to demonstrate the potentials of a computer support of the creativity techniques "brainstorming", "method 6-3-5", "lotus blossom" and "morphological matrix" and we are going to show how these techniques can be realized in a groupware. Especially creativity techniques like the "method 6-3-5", brainstorming or "lotus blossom" have the objective to produce large numbers of ideas in a short time. At the end of such a creativity process these ideas have to be analyzed, selected and evaluated. We are going to introduce a computer support for an idea management and we are going to show the special possibilities of a computer support to realize an idea management.

1. Introduction

Creativeness is essential to develop innovations in business, education and research communities. In the organizational context innovation may be linked to performance and growth by improvements in e.g. efficiency, productivity, quality, competitive positioning and market share. Innovation is defined as the introduction of something new, a new idea, method or device or the successful exploitation of new ideas [4]. For Schnetzler innovations depend on valuable ideas which are of economic relevance [8]. Valuable ideas are simple, surprising and relevant. These ideas combine extremes. They dare a lot but they can be realized easily. Valuable ideas are scientifically perfect, but also highly innovative. But valuable ideas are typically not produced without any effort. The generation of new ideas or concepts is often called creativity. Sternberg identifies creativity as the ability to produce work that is both novel (i.e. original and unexpected) and appropriate (i.e. useful and adaptive concerning task constraints) [9]. Creativity is a mental process involving the generation of new ideas or concepts, or new

associations between existing ideas or concepts. For Boden human creativity is something of a mystery, "not to say a paradox" [1]. One new idea may be creative, while another is merely new.

Most research and writing on creativity has focused on individual creativity, the "lone genius" with little recognition of the social and group factors that influence the creative process [7]. But with the growing necessity of specialization, the development of innovations will increasingly require group interaction at some stage of the process. In order to facilitate creativity processes in a group of people heuristic methods - called creativity techniques - are used. Generally most creativity techniques use associations between the goal, the current state and some stimulus. Boden distinguishes between three forms of creativity [1]. The first one involves making unfamiliar combinations of familiar ideas. The second one concerns the exploration of connectional spaces in people's mind and the third one involves the transforming of this space. Knieß makes a distinction between intuitive and systematically analytical creativity techniques [3]. The systematically analytical creativity techniques correspond to Boden's "making unfamiliar combinations" and the intuitive techniques correspond to the two other categories of Boden. As intuitive techniques Knieß distinguishes between techniques based on the strategies association, confrontation and orientation. Creativity techniques supporting intuitive associations are e.g. brain storming and brain writing. An example for a systematic analytical technique based on confrontation is the morphological matrix.

2. Idea Production

2.1. Brainstorming

One of the early proponents of group creativity is Alex Osborn [6]. In 1941 he promoted group brainstorming, a process of exchanging a large number of ideas in a non-evaluative setting. Osborn believed that the unfettered exchange of ideas would stimulate additional novel ideas among group members. Therefore he stated that group idea exchange would be a very effective measure to enhance creativity. Michalko characterizes

brainstorming as a group of people meeting to make a sculpture. Everyone brings a piece of clay to the meeting and places it on the table [6]. The pieces are molded together into a core and then the sculpture is turned, rearranged, modified, reduced, expanded and otherwise changed until the group agreed on the final sculpture. The idea of the brainstorming technique is to create an uninhibiting environment that will encourage imaginative ideas and thoughts. While a group of six to twelve people are discussing a problem one member is recording the remarks and suggestions on cards which are placed visible for all team members. The discussion takes place without any judgment on the suggestions of other participants. The main principle of a brainstorming session is "quantity breeds quality".

We realized a computer-supported brainstorming during which each participant records his ideas by himself on cards. These cards are placed on a shared virtual board. The cards are initially placed systematically by the system but the author of a card can move it anywhere on the board. If there are no more slots available on the board the board is widened automatically. New cards are immediately synchronized with all participants. In order to support the participants to maintain an overview of the ideas and the interrelations between them each participant can label cards with colors. These labels are only used locally. Whereas the position of the cards is exchanged between the participants the labels stay the same. They are only used to support the user to make a pre-organization of the ideas.

2.2. Method 6-3-5

The creativity technique "method 6-3-5" is a brain writing technique which belongs to the category supporting intuitive associations. Brain writing techniques force the members of a team to write down their ideas and to share them with other team members. The other team members pick up these ideas and use them as associations for further ideas. In an ideal case six persons work together on this technique, but there can also be less than six persons. In the ideal case each of the six participants writes down three ideas onto a piece of paper. After five minutes each team member has to pass his or her piece of paper on to his or her neighbor on the right. During the next five minutes each team member has to write down again three ideas onto the paper which has been passed on to him or her. Each participant can write down completely new ideas. He or she can also use the ideas already written down, create associations and that way further develop the ideas on the paper. After five minutes all participants have to pass on their piece of paper again to their neighbors on their right. After each participant has worked on each piece of paper the idea development is finished. In the ideal case 108 ideas can be elaborated in 30

minutes. The potential of the "method 6-3-5" is that all participants are particularly encouraged to continue the development of ideas which have been written down by other participants in previous laps of work. This method ensures an indirect social interaction between the participants. The participants are not interrupted while elaborating new ideas.

The synchronous approach of work in a face-to-face project can be dissolved in a computer supported scenario. The ideas can be worked out asynchronously by each participant in a time slot of 5 minutes. After all participants have worked out their ideas the form is passed on to the next participant. Instead of a moderator a groupware can take care of the control of the time. The social pressure can be eliminated by an anonymous work on the "method 6-3-5". A computer support of the "method 6-3-5" offers the moderator the opportunity of observing and reading the ideas while the participants are filling in their forms. Before the forms are circulated the moderator can determine how the forms will be redirected so that forms containing similar ideas will not directly be exchanged. The software can support the moderator in identifying forms with similar ideas by highlighting similar key words so that the moderator is able to identify these easily. But also in a setting where no anonymity is chosen different strategies to pass on the forms can be chosen. There can be a corresponding strategy as in a face to face setting, where the successors are determined at the beginning and where all participants know this sequence. It is also possible that the participants do not know in advance in which order the forms will be passed on.

METHOD 6-3-5 - PARTICIPATE ON SESSION
 Round: 001, Future Concepts of Computer Games

1. This round of the players must be supported in a short, comprehensible way.	2. Round 1 should be presented in a way that all players can see it (e.g., on a screen).	3. Round 2 should be presented in a way that all players can see it (e.g., on a screen).	4. Round 3 should be presented in a way that all players can see it (e.g., on a screen).
5. Round 4 should be presented in a way that all players can see it (e.g., on a screen).	6. Round 5 should be presented in a way that all players can see it (e.g., on a screen).	7. Round 6 should be presented in a way that all players can see it (e.g., on a screen).	8. Round 7 should be presented in a way that all players can see it (e.g., on a screen).

Figure 1. Screenshot of a method 6-3-5 session on "future concepts of computer games"

A screenshot of a method 6-3-5 session with the topic "Future Concepts of Computer Games" is shown in figure 1. In the form presented in the figure already two people have filled in their ideas. The third team member is now working on the form.

2.3. Lotus Blossom

The creativity technique "lotus blossom" is a systematic, analytical technique. The strategy behind is to organize creative thinking around core themes. The blossom begins with a core theme that evolves other themes and sub-themes that are interconnected, and those evolve a new pattern. Matsumura developed the lotus blossom technique that diagrammatically mimics [5]. Matsumura painted his

ideas on the pattern of a lotus blossom. This pattern is similar to a spreadsheet. Michalko describes the procedure of the lotus blossom technique that the petals or themes around the core of the blossom are figuratively peeled back one at a time, revealing a key component or subtheme [6]. The central theme is written down in the center of the lotus blossom diagram. In the circle around the center fields are available for at maximum eight ideas which add value to the theme in the center. In the next step each of these ideas is used as the center of a new lotus blossom and 8 new ideas are written down in the circle around each idea. This approach is pursued in ever-widening circles until the problem is comprehensively explored.

The computer-supported lotus blossom is an intuitive reproduction of the face-to-face diagram. The computer support offers an easy navigation through the different circles of the lotus blossom. Each change in the blossom by a participant is synchronized with the blossoms of the other participants immediately. The synchronization of the ideas ensures that the participants can use the results from other participants to stimulate new ideas. The participants can work as well synchronous as asynchronous on the lotus blossom. At the beginning the team manager defines a time slot for the work on the blossom. In a synchronous setting this is limited to 30 minutes or 1 hour. In an asynchronous setting the participants can work for several days on the blossom. Each participant regularly checks the changes in the blossom and adds his new ideas.

2.4. Morphological Matrix

The creativity technique "morphological matrix" is also a systematic analytical technique. New ideas and innovations are merely new combinations of existing bits and pieces. The morphological matrix snaps existing information together into provocative new patterns [6]. For the construction and the analysis of a morphological matrix Zwicky identified five steps [10]. The construction process of the matrix starts with a precise definition of the problem. This is the prerequisite for a general analysis by the matrix. This technique is called morphological matrix because the users have to identify in the second step the characteristics of the solution of a problem. These characteristics are filled in the first row of the matrix. In a third step they have to elaborate possible values for each characteristic. The elaborated values of a characteristic are filled in the cells being right of the cell in which the characteristic is shown. In the fourth step all interesting combinations of values of each characteristic are analyzed. These solutions build paths through the matrix. In each line of the matrix a cell with a value is marked. In the final step the optimal solution analyzed in the step before is selected. With a morphological matrix the

participants may see a connection between different characteristics and properties that will provide the stimulus for their imagination to fill gaps in the matrix [6].

For the computer support of the creativity technique "morphological matrix" we realized an approach where periods of individual work on the matrix are combined with work in a team. In the first phase we started with the individual work on the characteristics. In this phase each participant was asked to analyze the problem in detail by himself and write down its entire relevant characteristics. In this phase no participant could access the data of the other participants. The only person who was able to observe the individual work of the participants was the team manager. By this the team manager could ensure that participants who had misunderstood the task did not work on a wrong objective for a longer period. In the second phase the shared work on the characteristics of the problem started. The participants could see the characteristics of all participants which had been worked out in the first phase. In this phase the participants were supposed to work on associations which they derived from the ideas of the other participants. They should also look for gaps which had not been covered by the current list of characteristics. The authors of the characteristics were anonymous. When a participant did not understand a characteristic produced by another participant he could contact the author of the idea anonymously. In the third phase all participants had to compile a list of those characteristics which were relevant for the solution of the problem and which should be considered in the following phases. A subdivision in individual phases and shared phases was chosen to give the participants the opportunity to work in a concentrated manner on their own list of characteristics and their properties for these characteristics.

In the individual phases there was no pressure and no observation by the team. In the shared phases the participants should get inspirations from the characteristics and properties worked out by the others and they should work on the gaps in the matrix. The team manager could specify the beginning and the ending for each phase and each sub-phase. He was also able to decide that special phases should be cancelled e.g. that any individual work on properties was not necessary. If we analyze the task of developing a concept for a cooperative game as an example then the team has to work out first characteristics like "genre" and "representation" and then for each characteristic properties e.g. for the characteristic "cooperation" properties like "community" or "team". Finally a solution path has to be chosen.

In figure 2 is a screenshot of a morphological matrix in the phase "Shared work on optimal solution paths" is shown. For the task of developing a concept

for a cooperative game the team worked out first the characteristics like "genre" and "representation" and then for each characteristic properties e.g. for the characteristic "cooperation" properties like "community" or "team". The chosen solution path is highlighted blue.

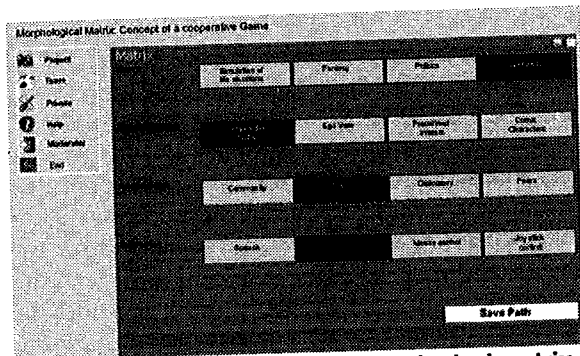


Figure 2. Screenshot of a morphological matrix session working on a concept of a cooperative game

3. Idea Management

The creativity techniques brainstorming, method 6-3-5 and lotus blossom produce a large number of ideas. An unstructured collection of these raw ideas is only a first step on the way to a solution to a predefined problem. The idea production must be followed by an idea management. During the idea management the best ideas fitting to the problem have to be selected. But this process is troubled by a lot of emotions. Usually the participants identify themselves most with those ideas they have contributed during the idea production phase. But, of course, the ideas which are ranked as very important by one participant may be ranked as low by another participant. It is nearly impossible to negotiate emotions during the idea management. An advantage of the computer support of the idea management process is that ideas can be evaluated anonymously so that emotions in the evaluation process can be reduced. Moreover the team manager decides which criteria the participants have to take into account when evaluating the ideas.

In our computer support approach of the idea management the management process is structured by the team manager. He can configure this process with the support of a phase manager. He can divide the team into smaller sub teams and assign tasks for these sub teams. Two main steps have to be done. First all ideas have to be evaluated and second the ideas must be organized in categories. The team manager can appoint sub teams with these two tasks. He specifies the beginning and end of the task. Both tasks can be handled in parallel or first the evaluation is done and later on the clustering. As a special case both sub teams can be identical and work sequential on both tasks. The team manager can also specify which creativity sessions should be considered in the idea

management. This could be e.g. a precedent lotus blossom session or e.g. the ideas from a method 6-3-5 plus a lotus blossom session. By this approach different idea production sessions can be brought and evaluated together.

Before the evaluation of the ideas starts the moderator has to specify the criteria which the participants have to use to judge each idea. Criteria could be whether the idea can be realized, the originality of the idea or the costs to realize an idea. The scales the participants have to use to judge each idea can also be adapted by the moderator at the beginning of this step. For the analysis of the results the criteria can be weighted by the moderator or by the participants. During the evaluation of the criteria the participants can post comments concerning their evaluation. These comments will be visible for all participants in later steps of the idea management. In some of the creativity methods the ideas are already pre-structured. In the lotus blossom the ideas have a tree-structure. In the method 6-3-5 the ideas are structured in forms. These pre-structures are visualized for the participants during the evaluation.

After the evaluation of the ideas has been completed a table of favorites is generated considering the evaluation results. It can be read by the complete team. For each idea in this table the mean and the standard derivation is shown. The ideas with a value concerning the mean and a low standard derivation are those ideas which should be considered for the following steps. The ideas with an average mean but a high standard derivation should be analyzed again by the team. The high value of standard derivation indicates that the participants disagreed concerning these ideas.

The second task to work on the raw ideas is to structure them by assigning them to clusters. These clusters can be defined by the participants themselves. As already mentioned before ideas produced by the lotus blossom and the method 6-3-5 techniques are already pre-structured. The participants can make use of these pre-structures. In this case all the ideas of a branch of a lotus blossom are automatically assigned to one cluster or all ideas on one form of the method 6-3-5 are assigned in one cluster. The participants can use this initial structure and change it. They can add new clusters and also refine existing clusters by adding sub clusters. The clustering of ideas is shown in figure 3. After the list of the favorite ideas has been completed and the ideas have been categorized into clusters. It is important to combine the results of these two tasks evaluating and clustering. In each cluster the high-rated ideas are presented bigger than lower-rated ideas. If necessary these clusters can be evaluated again as a whole. Therefore the team manager can assign again a sub team whose participants should work on this task.

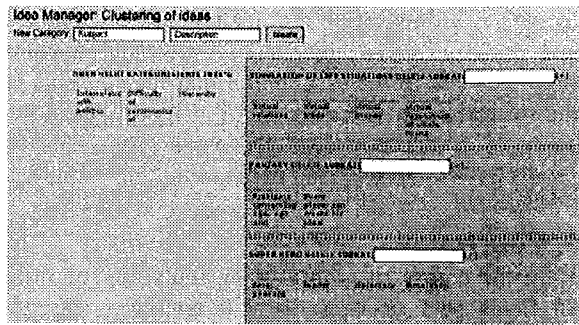


Figure 3. Screenshot of the clustering of ideas

At the end of the idea management you often have to extend the set of ideas again considering additional criteria as mentioned above. In creativity projects, for example, where the team has to work out innovative products for e.g. people who are younger than 25 years it could be helpful to identify all those ideas highly-rated by all those participants who are younger than 25. In these cases we can make use of the computer-based realization of the creativity techniques. In a face-to-face scenario we typically do not know who has written down a special idea. In a computer-based scenario the system is able to store this information so that we can fall back on it in later phases of work. This can again be done anonymously. The participants can only specify attributes like "has been written and positively evaluated by females". If we combine the ratings with the clusters identified before we can make use of the top ideas together with those ideas with an average rate belonging to the clusters identified before. At the end of the process we will have a list of ideas and their interrelations which can be used for an innovation management.

4. First Results

We analyzed the capability of our approach in several university student projects. In the following we will document the results of the analysis of four virtual project teams. In our study 29 participants worked part-time in projects. 19 participants were male and 10 were female. The age of the participants was between 21 and 27.

With the help of a computer supported team configurator [2] we divided the 29 participants into five teams. Our aim was to compose teams with two different profiles. Two teams had a high rate in the characteristic creativity and two teams were configured as conscientious and well-organized. As we only had a total amount of 29 participants the fifth team could not be composed considering a special profile. Therefore this team will not be incorporated in the following analysis. In the two creative teams the characteristic creativity was intended to be heterogeneous. This implies that only a few of the members of these teams were highly creative and the others differed in this characteristic. The two teams arranged to be conscientious and well-organized were

configured homogeneously. This means that all members had these characteristics. As there were only 29 students being at our disposal it was only possible to compose one team whose members were creative at a high rate and one conscientious team fitting into the profiles in the best possible way. By this the two secondly composed teams were supposed to be less effective than the first composed teams concerning their respective profile. The members of the teams were not informed which team profiles were used to compose the teams.

These five teams had to work on special tasks for three weeks. The tasks required an effort of each participant of approximately four hours per week. The participants worked anonymously using pseudonyms so that existing social relations between the participants could not influence the results of our study. At the beginning of the project work we used a virtual team game to build up a team spirit in the virtual team. This game makes the participants get to know each other without giving up their anonymity.

During the team work two teams worked on the task to elaborate future cooperative computer games and two teams had the task to work out a concept for the computer support of the design process of computer games in distributed teams. Each of the two tasks was handled by a creative team and by a conscientious team. In order to generate their concept the teams used our computer supported creativity techniques brainstorming and lotus blossom for their idea production and they assessed the worked out ideas with the idea manager.

	Total #	# Ideas on Levels of the Blossom			
		1	2	3	4
Creative Team 1	85	6	45	24	10
Creative Team 2	62	6	33	16	7
Consci. Team 1	76	8	48	18	2
Consci. Team 2	54	7	40	6	1

Table 1. Number of ideas produced by the two creative and the two conscientious and well-organized teams with the lotus blossom technique

We had chosen the tasks to work out concepts of future cooperative games and to work out a concept for the computer support of the design process of computer games because both tasks had a focus on working out innovations. We had assumed that the two creative teams would work out more innovative concepts than the two conscientious teams. In a first

step the teams worked out future concepts either for computer games or for the computer support of the design process of a computer game. This work was done with the brainstorming and the lotus blossom modules.

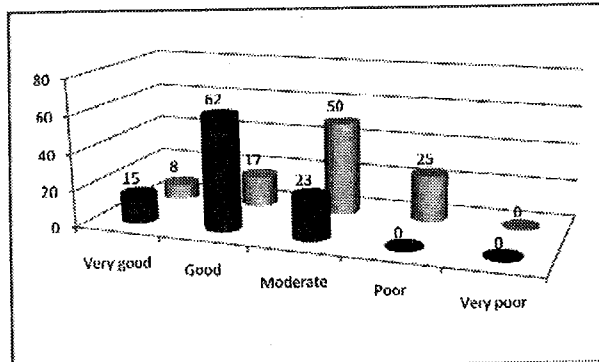


Figure 4. Innovation achieved by the firstly composed creative teams compared with the firstly composed conscientious teams during the first projects (front row creative team, back row conscientious team)

In table 1 exemplary the numbers of ideas produced by the four teams with support of the lotus blossom are listed. In the column total number of ideas all ideas produced in the lotus blossom are added. In the four columns "ideas on levels of the blossom" it is analyzed how many ideas the teams produced on the different levels of the blossom. The numbers for the first levels indicate e.g. how many of the 8 possible arrays of the blossom on the first circle around the center were filled up.

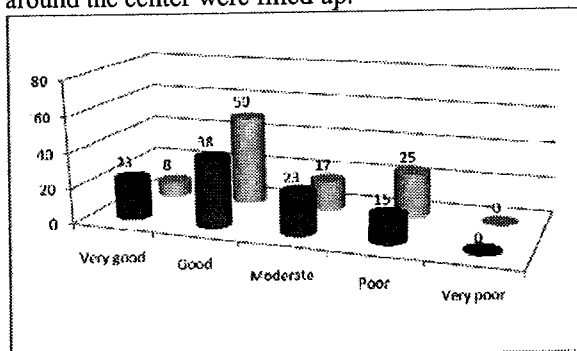


Figure 5. Innovation achieved by the secondly composed creative teams compared with the secondly composed conscientious teams during the first projects (front row creative team, back row conscientious team)

Table 1 shows that even if all teams produced a comparable number of ideas the two blossoms of the creative teams bloom in more detail than the blossoms of the conscientious and well-organized teams. At the end of the project each team documented their project results in a position paper which was written using a group editor. Finally these position papers were submitted into a conference tool (openconf) and each paper was reviewed by thirteen reviewers. The results of this evaluation concerning

the achieved innovation are documented in figures 4 and 5. These figures indicate that for these four teams we were right in the assumption that the concepts of the two creative teams are more innovative than the concepts of the conscientious teams. The achieved results have to be analyzed in detail in future studies.

8. Conclusion

In the course of globalization the competition in all fields gets stronger. New innovative ideas are needed to be able to compete with competitors. Companies do not longer stay at one location and operate in one country. Their subsidiaries are sometimes spread all over the world. In this paper we have introduced an approach that enables people to work together elaborating valuable ideas. We have discussed the potentials of a computer support for the creativity techniques "brainstorming", "method 6-3-5", "lotus blossom" and "morphological matrix". For globally operating companies it is important to produce products which will be accepted in different cultures. We have explained the potentials to work on ideas in teams and we have shown the possibility to compose teams with different profiles. By this approach we can also configure teams with participants belonging to different cultures. We have introduced four creativity techniques and explained the potentials of a computer support of these four techniques. For the analysis of quantities of ideas we have realized an idea management module and we have shown the possibilities of a computer support of an idea management compared with a creativity process operated without a computer support.

10. References

- [1] Boden, M.A., *The creative mind: myths and mechanisms*, Routledge, London; New York, 2004.
- [2] Donker H, M. Blumberg, How to compose your dream team? Proceedings of the Fourth International Conference on Collaboration Technologies 2008, Wakayama, 2008.
- [3] Knieß, M., *Kreatives Arbeiten*, DTV, München, 1995.
- [4] Merriam-Webster Online Dictionary. Innovation. 2005.
- [5] Michalko, M., *Cracking Creativity*, Ten Speed Press, Berkley, 2001.
- [6] Michalko M., *Thinkertoys*, Ten Speed Press, Berkley, 2006.
- [7] Paulus P.B., B.A. Nijstad. *Group creativity*. Oxford University Press, Oxford, 2003.
- [8] Schnetzler N., *Die Ideenmaschine*. Wiley-VCH, Weinheim, 2005.
- [9] Sternberg R.J., *Handbook of creativity*. Cambridge University Press, Cambridge, 1999.
- [10] Zwicky F., *Entdecken - Erfinden - Forschen im morphologischen Weltbild*. Droemer Knaur, München, 1971..