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SUPPORTING CREATIVITY IN CONCEPTUAL DESIGN: METHOD 635-EXTENDED

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1. Introduction

Creativity plays an important role within the development of new solutions in product development. Especially in conceptual design where solutions are developed on the level of working principles as well as through first shape and form concepts, different idea generation methods find application to support creativity. One creativity technique often used in products design is Method 635. However, the application on various conceptual design problems showed that Method 635 does have problems in supporting creativity processes in the development of shape and form concepts. This paper represents an approach that focuses on solving these problems and thus gives a suggestion, how Method 635 can be modified to be a powerful method for developing shape and form solutions in conceptual design.
The paper is structured as described in the following. In the background (section 2) Method 635 and other idea generation methods will be presented before problems in their application in conceptual design are characterized by means of a model for product concretization. Section 3 depicts the approach to tackle the identified problem before a workshop concept for a modified method application will be derived. Section 4 exemplifies the application of the modified method within a case study. Section 5 discusses and interprets the results of the case study before a conclusion summarizes the findings of this paper and gives an outlook in Section 6.

2. Background

Idea generation methods are well known and applied in various areas and through different disciplines to support the generation of solutions for all kind of problems. Developers and designers often apply them in the field of product development to foster the generation of solutions for (technical) problems.

2.1 Methods for idea generation and the Method 635

The cognitive mechanism or heuristic embodied by idea generation methods broadly classifies the different techniques into two groups [Schlicksupp 1999]. On the one hand there are systematic-analytical methods which support systematical problem decomposition and analysis and aim at increasing the comprehension of a system to enhance the quality of new ideas [Ulrich and Eppinger 2004]. On the other hand there are methods that focus on animating human's intuition by stimulating the unconscious thinking process of the human mind [Shah, et al. 2001]. Shah et al sub-classifies the latter ones which are also called creativity techniques further into five categories: germinal, transformational, progressive, organizational, and hybrid methods [Shah, et al. 2001] as depicted in figure 1.
The following refers to Method 635 as it constitutes the fundament for the approach presented in this paper. Based on the finding that brainstormings are particularly successful when ideas of a team member are picked up and evolved by the others Prof. Bernd Rohrbach developed and introduced

Method 635 in 1969 [Rohrbach 1969] as a specific form of brainwriting. As other brainwriting techniques it aims at tackling brainstorming problems like a creativity barriers as consequence of interpersonal conflicts or cultural status differences existing among the group members [VanGundy 1984] as well as on the identification of idea producers for reasons of intellectual properties [Rohrbach 1969]. Although stemming from the groups of brainwritings, Method 635 belongs to the group of progressive methods as ideas are generated in discrete progressive steps through repeating the same set of steps a number of times under constant inspiration by foreign ideas.

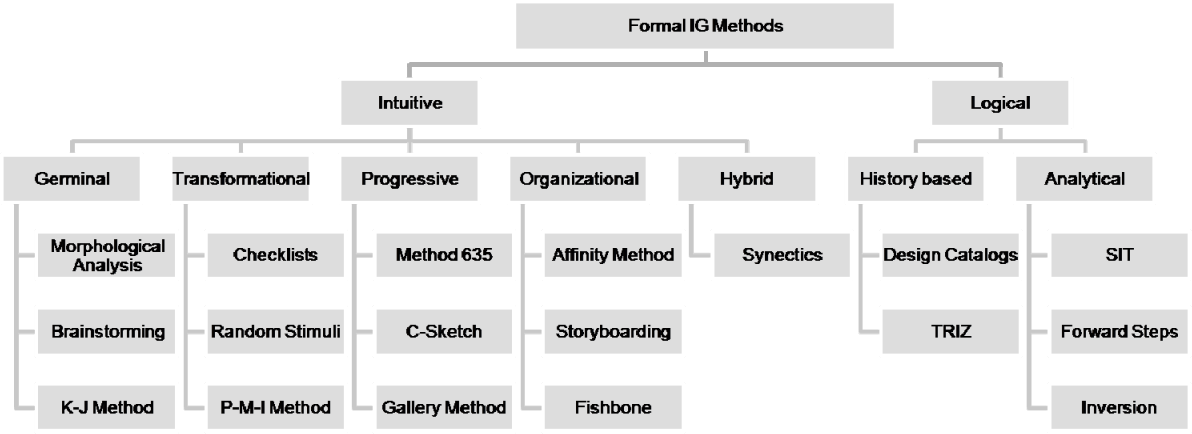

Figure 1. Classification of idea generation methods based on [Shah, et al. 2000]

The basic procedure underlying Method 635 is that six designers develop and write down three ideas within a defined timeframe of three to five minutes before passing their ideas to the neighbor or subsequent designer. In the next step each team member has to evolve ideas based on the ones given through her/his predecessor. This can happen by modification of existing ideas or developing even new ideas inspired by the given ones. This procedure is continued until each team member receives his initial sheet of ideas, which should happen after five rounds considering 6 participants. In result 18 initial solutions are evolved five times from five different point of views [Rohrbach 1969].
To better understand where, when and how the group of creativity techniques and especially Method 635, find application within product development the following summarizes product representations and their concretization levels within a product development process.

2.2 Abstraction levels of product presentations

Based on an idea for a product the generation and development of solutions takes place on different abstraction levels during a product development process before eventually a new product is completely defined. To examine in how far the application of idea generation methods differs according to the abstraction levels on which a solution has to be generated it is helpful to identify certain “discrete” steps within the product concretization of a design process. The Munich Model of Product Concretization [Ponn and Lindemann 2008] does this through four subordinate product state levels which incorporate different product representations (see figure 2) and are iteratively run through during a product design process. On a first level requirements to the new product (1) are defined (which will be further detailed through the whole concretization) before the product will be described in a very abstract way on the level of its functions (2). The next higher concretization level represents the product by its active principles (3), such as physical (and/or chemical) effects and their interaction. The highest concretization level (4) carries out the final product design by their final components and their structure. Besides technical aspects such as the product architecture with all its components and their interfaces, the final product design comprises non technical design properties that consider ergonomic aspects as well as appearance through material, form, shape and surface and color. Within the described model the shape and form design is determined somewhere in-between level (3) and (4) [Ponn and Lindemann 2008].

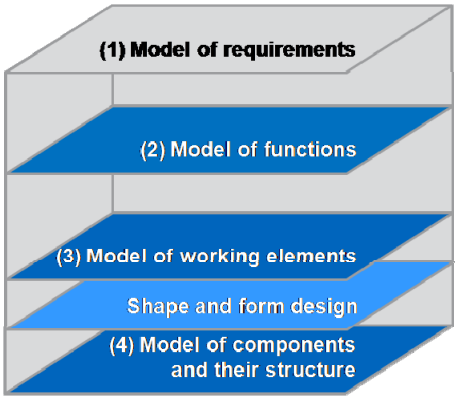

Figure 2. The Munich Model of Product Concretization [Ponn and Lindemann 2008]

In regard to a differentiation of concretization levels such as in the Munich Model the generation of solutions emerges on almost any level from first abstract functional product descriptions (where alternatives of functional behaviors can be carried out) down to the very concrete level of product design through different shape or form solutions or even surface and color characteristics. From an interdisciplinary point of view of industrial and engineering design conceptual design consists of determination of working principals on level (3) as well as of the development of first shape and form design. This paper focuses thus only on elaboration of solutions on these two levels.

2.3 Application of idea generation methods in conceptual design

The previous section summarizes a model of product concretization that was developed to visualize how the product representation evolves during a product development process. The following discusses the application of methods for idea generation and visualization on level (3) and on the way to level (4) to demonstrate their employment within conceptual design.

2.3.1 Application of idea generation methods on level of "working elements" (3)

Similar to the abstract and strategic search of new product ideas, one often applies idea generation methods to support the relatively abstract search of solutions for technical problems already represented through functional models (2). These solutions are then represented on the level of working elements (3) through abstract physical (or chemical) effects rather than through concrete shape or form designs.

However, even within these rather abstract levels of product development a shift of visualization media succeeds the concretization of the product representation. While abstract product ideas are often communicated word based (spoken or written) in brainstorming and brainwriting sessions the visualization of (first abstract) solution ideas often employs sketches and drawings. This shift of visualization media occurs as well in the application of Method 635 that this research tackles. While Rohrbach suggested writing down the ideas within his original description of the method when he introduced it for problem solving in general [Rohrbach 1969], Method 635 is commonly used within the field of conceptual design by employing sketches to document the ideas because auf two reasons. (1) Imagery and visual thinking encourages designers to think on a more abstract level [Verstijnen, et al. 1998] which enhances the idea generation process and (2) pictorial or graphical representations are more flexible and thus ease the transformation of ideas [Tovey 1986]. This modification relates to the development of collaborative sketching (C-Sketch) which was originally proposed by Shah under the name 5-1-4 as modification of Rohrbach's method [Shah, et al. 2001]. However, the visualization of ideas or solutions remains within a two-dimensional space.

2.3.2 Idea generation on level of "shape and form design" (between 3 and 4)

While on the former described abstract level of working principles and concepts (3) creativity techniques and their different heuristics are applied combined with various two-dimensional visualization media the evolvement of more concrete product representations as shape and form

designs often takes place without explicit application of any of these creativity techniques. Instead, the variety of employed representation media is greater and doesn't remain in a two-dimensional space. Especially disciplines as industrial design focus strongly on using three-dimensional product representations in form of early (and often rough) prototypes to visualize shape and form ideas. For this purpose one can employ different physical 3D modeling techniques to enforce generation, development, visualization and communication of ideas. This shift to the 3D-product representation depicts somehow a continuation of the above mentioned change in representation media from spoken or written word to graphical representations as sketches and drawings that follows the concretization of the product itself.
Summarizing these observations leads to the following assumption that is visualized in figure 3.
For evolving ideas on lower concretization levels, where functional descriptions by means of working principles and concepts support product representation, various creativity techniques are used to explicitly take advantage of known heuristics while the idea visualization happens only by simple means as spoken or written words or simple graphical representations as sketches and drawings. In contrast, creative stimuli given by these heuristics through known creativity techniques are not explicitly used on higher concretization levels of shape and form design while employed visualization media incorporates a shift to 3D visualization.

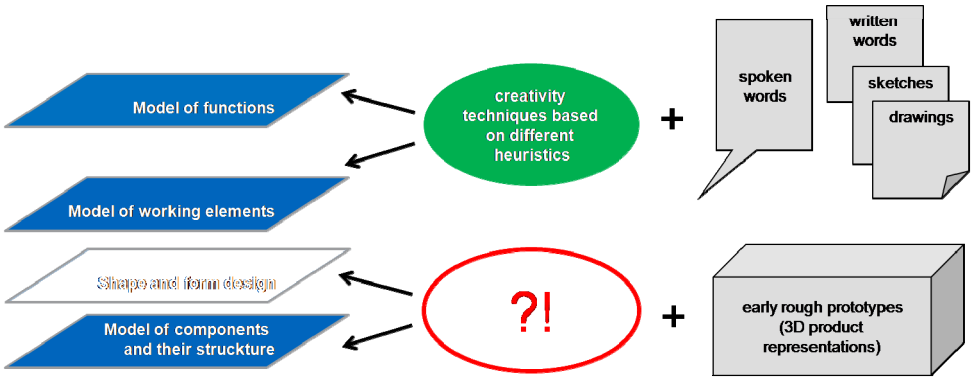

Figure 3. Application of creativity techniques and visualization media on different levels of product representation

Applying the known cognitive mechanisms (resp. heuristics) that underlie creativity techniques within idea generation on higher concretization level is still estimated by the authors to be reasonable. However, the attempt to employ a sketch based Method 635 on a higher concretization level showed that this cannot happen without adaptations. Different workshops in the fields of sports and other consumer products showed that just very few new solutions where generated upon a certain number of passes/rounds as workshop participants had difficulties to express their ideas on paper. From that point on only minor concretizations could be observed within the ongoing idea generation workshops. Together with the observed change in representation media in the generation of shape and from designs this leads to the assumption that the application of creativity techniques as Method 635 – or at least their powerful heuristics – can be successfully applied on higher concretization levels if adaptations are made concerning media for documentation and thus visualization and communication within the application of the method.
How the method could be modified and in how far this modification supports the application of the underlying heuristic on the focused level of concretization will be presented in this paper.

3. Approach: Extension of Method 635

Applying Method 635 in a reasonable way on the higher concretization level of shape and form designs is the aim of the work summarized in this paper. As described in section 2 an unmodified employment of the method didn't lead to the desired results within a series of performed workshops. In the following an adaptation of Method 635 is presented that tries to solve the observed problems. While the general idea as well as the procedure is described in 3.1 a derived workshop concept will be presented in 3.2.

3.1 Idea and procedure

The idea behind the proposed approach is basically to combine the given creativity technique of Method 635 with visualization media that already finds application in the elaboration of solutions for the shape or form design of a product (concept). Therefore the proposed approach starts with a classical brainwriting of the Method 635 which incorporates the employment of sketches (similar to C-Sketch) completed through their textual description. Instead of remaining on 2D (paper) based visualization media a shift to 3D modeling is conducted after a certain number of rounds/passes. The point in time where this shift has to be conducted is to be set for each problem. A good reference point seems to be to shift after the fourth round as in the former mentioned Method 635 workshops the productivity of idea generation often seemed to reach saturation after four rounds.
From this point on the team members of the creativity session are provided with various modeling materials and tools and have to elaborate and visualize their ideas by rough prototypes instead of sketching them to continue the adapted Method 635 session. Provided Materials for these modeling activities could be paper and paperboard, wire and wire nets, different foils (e. g. bubble foil) and tapes (single and double sided), modeling clay, different foams, different types of glue, etc. Based on the former developed and 2D visualized ideas they are now urged to further develop these ideas by means of these different modeling materials (see figure 4).

Figure 4. Materials for "real" 3D Visualization through early (rough) prototyping

As pictured in figure 5 the creativity session will now be continued in terms of its procedure as within the standard Method 635; the results of the first modeling session will be handed over to the next team member in round who then has to modify and evolve the model again.

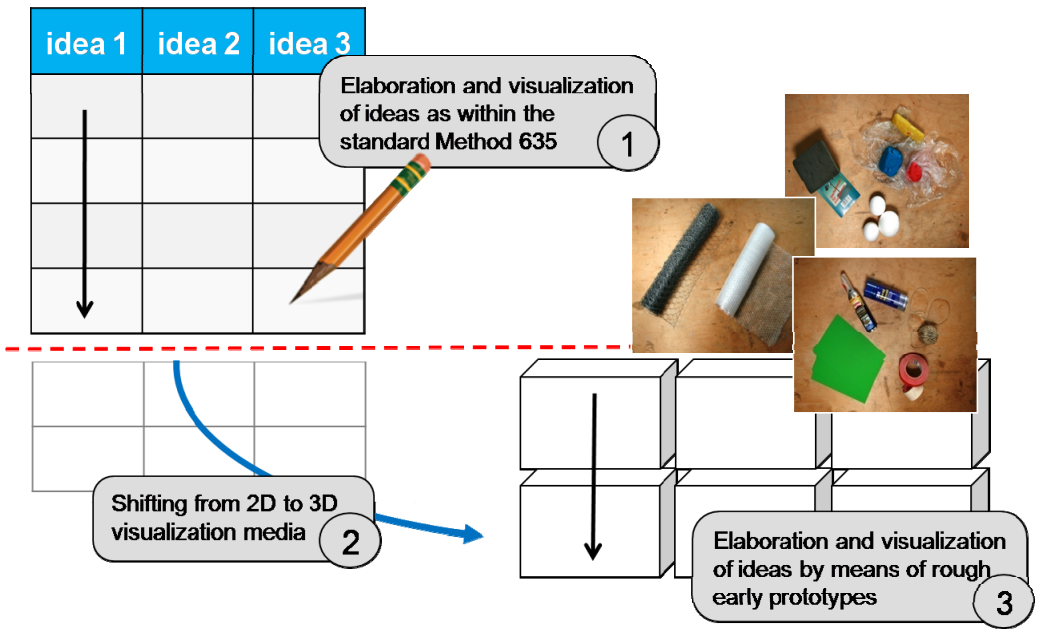

Figure 5. Idea and procedure of adapted Method 635

3.2 Workshop Concept: "Method 635-extended"

According to the increased time required for building (even only a rough) 3D models compared to drawing or sketching the expenditure of time for developing and visualizing the ideas within each 635 cycle needs to increase. Thus the provided time in each round has been set up. However, the limitation of elaboration time remains still as an important factor of the Method 635 since the resulting stress is expected to enforce creativity. Keeping these two aspects in mind the elaboration time was set between 20 and 40 minutes per round. The exact point is recommended to be kept flexible and to be determined by a neutral moderator who keeps an eye on the idea generation progress.
Since the allover workshop duration would escalate through the elongation of elaboration time within a round further adjustments have to be made to keep up motivation and productivity (besides creativity) within workshops employing the modified Method 635. The reduction of ideas/solution alternatives to evolve during one round is a feasible option. Thus each team member would model just one or two of the three given ideas handed over by its neighbor after the last 2D round.

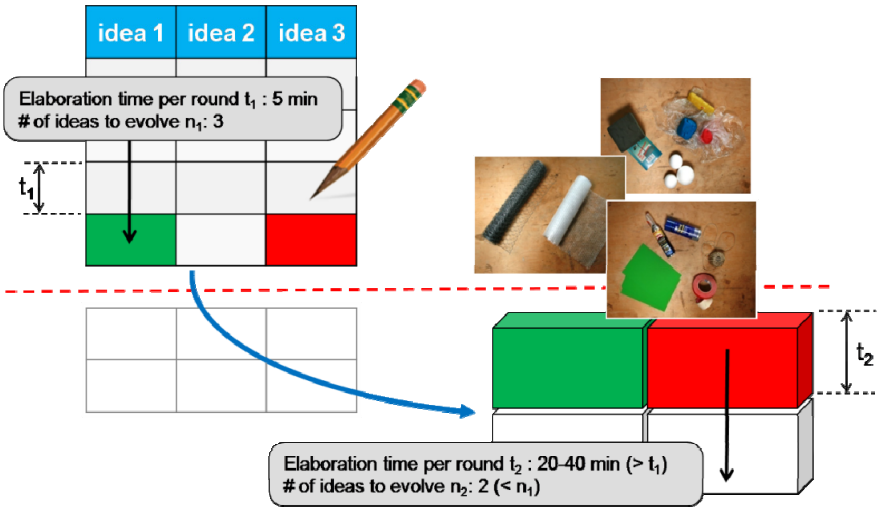

Figure 6. Adjusted Method 635-exended

The selection of these one or two solutions could be a crucial point and can happen on different ways. As various variables influence this selection process it'll be further discussed in section 5. Figure 6 gives an overview over the different steps of the combined method to help understanding the procedure within a "Method 635-extended" creativity session.
Besides these adjustments there are further influencing parameters that give a certain freedom to adjust the modified method to the special situation. In particular these are: (1) the number of rounds performed within the standard Method 635 approach before shifting from 2D word and sketch based visualization to 3D modeling, (2) the modeling process which can happen for each member on his own as in the standard Method 635 or within small sub teams of 2 or 3 people, and (3) the provided materials for modeling the solutions. In how far these parameters could be varied within a creativity session to adapt to a special product development problem will be discussed in section 5.

4. Case Study

This section illustrates the proposed workshop concept. As detailed a shift of visualization media extends the Method 635. The workshop took place at university with participants from both industry and academia and lasted 3 hours. The company is in the business of power tools and is well known as working methodically in product development. The task of the workshop was to conceptualize a grip for a hand-guided power tool. This sample was chosen because it considers the concretization of shape and form design based on given working principles as mentioned. A research assistant from the institute, methodically skilled and experienced, moderated the workshop, which was the first one with this proposed method. The workshop tackled a problem formulation, which has been elaborated in advance iteratively by the moderator and one student member. Due to its importance for reaching the

project goal and challenging character, a workshop with several participants was considered an appropriate means. The proposed method supported tackling this problem formulation of developing ideas for a form and shape design. The media shift in Method 635 has been announced in the workshop introduction.

4.1 Participants

Three industrial guests, two research assistants from the institute, two students from the institute and one student from another technical university participated in the workshop. The team consisted of both female and male members with an age between mid 20 and 45. Everybody of the academic workshop participants at least had some experience in applying creativity methods. All of the participants were mechanical engineers, but at least two students and the moderator are active in the field of industrial design engineering.
The industrial participants were all dealing with product development, but in different departments. The workshop addressed a problem formulation which the industrial participants were familiar with. All of them had a degree in mechanical engineering and at least a few years of experience in product development. There were no major hierarchical differences except experience and corporate affiliation.

4.2 Procedure

All participants sat around one conference desk next to each other and two real hand-guided machine tools were available, on which the handle would be mounted. The workshop participants had been introduced to the specific problem briefly.
The first part of the workshop targeted the shape of the handle for several applications. A sketch based Method 635 supported deriving a range of solutions visualized on a paper form. Each participant drew 3 solutions on a form and added some comments if necessary to support understanding the basic idea expressed by the scribble. After a time of 5 to 7 minutes the participants passed the paper sheets to the right hand side sitting mate synchronously. The already drawn solutions could excite and stimulate the evolution of existing solutions and generation of further ones.
After the fourth passing the moderator announced a media shift. As in paper based Method 635 participants based their work on the already generated solutions by their predecessor. The workshop introduction had already prepared the participants for this media shift and they already were aware of the available material. Some instructions guided the participants to fulfill this task: (1) Do not regard scale of the solutions in relation to the real hand-guided machine tool, (2) it is only rough prototyping, do not get lost in details, (3) the prototype is in “statu nascendi”, feel free to evolve the prototype.
At the media shift, the depicted solutions have still been drawn on 2D media and stimulated the emergence of solutions prototyped in 3D. The participants grouped together in teams consisting of 2 people and chose one solution to further evolve it in 3D. These prototypes could be easily evaluated during creation due to mounting at or comparison with the available real machine tools. They supported rough estimations if further concretization of the idea would be worthy.

Figure 7. Solutions applied to the real machine tool

Despite the basic procedure of Method 635, the small teams only generated at least one or more solution instead of 3 in paper based 635. Pictures documented the solutions before passing again. After the next passing, participants were asked to further evolve the solution, which was already realized by

a prototype. Instead of getting inspired by drawings now a 3D prototype stimulated the evolvement of the solution. Finally each participant presented the final prototype to all of the participants by applying it to the real machine tool (see figure 7). A discussion of the workshop resulted and a feedback considering the applied set of methods closed the workshop session.

5. Interpretation and Discussion

The following discussion is based on experiences made within the former described case study workshop and consists of direct feedback from the participants of the workshop as well as of observations by the moderator and a team member who are the authors of this paper.
As the presented approach is based on a modification of Method 635, the discussion is structured by the different consequences of the modification as well as by the different means of adaptation that result out of the modification.

5.1 Selection of solutions before media shift

As depicted in section 3.3 the standard procedure of Method 635 had to be adjusted to an increased elaboration time for modeling (which is necessary to achieve satisfying results). As the allover duration of the workshop should at the same time be limited the number of solutions to model after the media shift had to be reduced. As consequence solutions had to be (pre)selected before the shift in visualization media. Within the depicted case study workshop the materials and tools to elaborate physical 3D representations of the ideas were presented before the workshop participants selected the solutions they wanted to develop further. In consequence the awareness of modeling materials influenced the selection of solutions as participants preferred solutions they estimated easy and good to model with the given materials. As the selection of solutions has to be independent of given modeling materials and tools and only be oriented at the given task (requirements to the product), it must not be communicated before the selection process. In how far the shift in visualization media needs to be communicated at all before it takes place (e.g. at the beginning or within the workshop) might be another mean to influence a workshop, but won't be further discussed in this paper. Apart from the given information concerning materials the way of (pre-)selecting solutions is an important parameter to influence the quality of workshop results. An alternative to the independent selection through every participant based on the received 635 sheet is a common evaluation and selection process of all solutions (of the last round) through all team members. This would have the advantage of taking into account knowhow and experiences of all involved participants with their (disciplinary) background. However, such a common selection process takes a lot more time and disrupts the continuity of the workshop. Furthermore interpersonal conflicts or cultural status differences existing among the group members can influence such a common selection process. A random selection of solutions would be another alternative that could help coping with the mentioned problems, but will not further be discussed in this paper.

5.2 Modeling alone or in (small) teams

Within the depicted case study workshop small teams of two people evolved the given ideas after the media shift to 3D by means of rough prototypes. This presents a modification of the standard procedure of Method 635 where each team member evolves and visualizes his ideas on his own. On the one hand the purpose of this modification was to balance the varying modeling skills of the different team members; to catch up on these skills in advance is thus a duty for the moderator. On the other hand the mutual idea generation as it is known in methods like brainstorming and brainwriting was to be expected as a refreshing factor at this confrontation with "new" visualization media and at a point in time where first signs of exhaustion were expected and observed. However, in the configuration of these teams, personal backgrounds as e.g. personal conflicts have to be considered. Especially differences within the hierarchical positions of team members could generate negative stress to participants exposed to the "new" task of modeling 3D models and should thus be avoided.
In how far modeling in small teams or individually leads to better results can't be determined in this paper. However, the constitution of the modeling phase seems to influence the workshop and is thus considered as another mean to adapt the evolved Method 635 to the special situation.

5.3 Provided modeling materials

In 5.1 the communication of modeling materials and its influence on the decision process was already discussed. As participants anticipated in the workshop, the selection of modeling materials and tools influences the possibility to model and thus impacts the feasibility to evolve, visualize and communicate a solution. Besides advising to provide a preferably large pool of materials no general recommendations can be given. In fact the provided set of materials should give enough diversity to model all kinds of solutions. The composition of a material set appropriate to the given problem represents thus as another important mean to adapt the presented method.

5.4 Moment of media shift

The focus of the former described and applied method lies on a shift in visualization media within the idea generation process by means of Method 635. However, when this media shift has to happen isn't determined through the method. Although suggested in section 3.1 to happen after the fourth round/passing within the standard Method 635 procedure it seems to be reasonable to keep this point flexible and employ it as another parameter to adapt the method to the special problem/task.
As Knieß describes, the production of ideas within a group typically follows a wave-curve [Knieß 1995] as depicted in figure 8. After the team got confronted with the given problem it starts to develop ideas. In a first phase the productiveness of this idea generation process increases while the team members become more and more familiar with their task. Thus the development of new ideas decreases upon a certain point caused by a diminishing stimulation. This leads to saturation in the idea production process. However, a second maximum in the idea production could be reached if the moderator gives new stimuli to the group [Knieß 1995] by e.g. giving further information to the problem or possible directions of solutions.

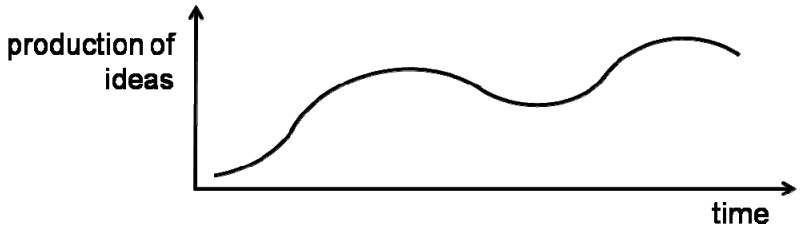

Figure 8. Idea production over time within a group [Knieß 1995]

Signs like bored team members and only minor progression within the solution development indicates such saturation. Realizing them requires an experienced and attentive moderator.

6. Conclusion

Within this paper an approach was introduced to tackle the problem of barely utilized creativity techniques (and their heuristics) in the elaboration of shape and form designs in conceptual design. This approach consisted of supplementing the given Method 635 by means of further visualization media for modeling early 3D prototypes. Based on the basic idea a workshop concept was derived and exemplarily deployed in a case study. The results of the workshop – underlined by the observations of the moderator and feedback of workshop participants – showed that the application of the modified method leads to convincing solutions and thus to support the generation of shape and form designs in the special case. The variety of suggested means to adapt the presented method to other development tasks is large and promises expansive adaptations to a wide field of problems. However, especially the interaction of these means hasn't been examined so far and needs thus be explored in further workshops. Furthermore future work needs to focus on the evaluation of the presented method (extension) as it was conducted for other methods e.g. by [Shah, et al. 2000].
In how far a media shift may bridge several methods in general and thus give an impetus to the generation of ideas is another topic resulting out of the media shift conducted in the presented work and should be examined in future work.

References

Knieß, M., "Kreatives Arbeiten", DTV-Beck München, 1995.

Ponn, J., and Lindemann, U., "Konzeptentwicklung Und Gestaltung Technischer Produkte", Springer Berlin, 2008.

Rohrbach, B., "Kreativ Nach Regeln - Methode 635, Eine Neue Technik Zum Lösen Von Problemen", Absatzwirtschaft, 12, No.19, 1969, pp. 73-75.

Schlicksupp, H., "Innovation, Kreativität Und Ideenfindung", 1999.

Shah, J., Vargas-Hernandez, N., Summers, J., and Kulkarni, S., "Collaborative Sketching (C-Sketch) - an Idea Generation Technique for Engineering Design", The Journal of Creative Behavior, 35, No.3, 2001, pp. 168-198.

Shah, J. J., Kulkarni, S. V., and Vargas-Hernandez, N., "Evaluation of Idea Generation Methods for Conceptual Design: Effectiveness Metrics and Design of Experiments", Journal of Mechanical Design, 122, 2000, pp. 377.

Tovey, M., "Thinking Styles and Modeling Systems", Design Studies, 7, No.1, 1986, pp. 20-30.

Ulrich, S. D., and Eppinger, K. T., "Product Design and Development", McGraw-Hill New York, 2004.

VanGundy, A. B., "Brain Writing for New Product Ideas: An Alternative to Brainstorming", Journal of Consumer Marketing, 1, No.2, 1984, pp. 67 - 74.

Verstijnen, I. M., van Leeuwen, C., Goldschmidt, G., Hamel, R., and Hennessey, J. M., "Sketching and Creative Discovery", Design Studies, 19, No.4, 1998, pp. 519-546.

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