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TRIZ-BOX IN DESIGN EDUCATION - A STUDY ON SUPPORTING CREATIVITY

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ABSTRACT
Creativity is an essential part of innovative product development and the origin of successful products. Several methods support creative activities. The method introduced in this paper is called TRIZ-Box. Its key concept is to connect the inventive principles of TRIZ with artifacts that represent those specific principles in a functional, technical or physical way.
The study presented in this paper considers the analysis of TRIZ-Box within the tutorial sessions of an educational product development project. It focuses on the research of supporting creativity. For that purpose 42 participant students have been asked about the quantity and quality of the solutions they generated applying TRIZ-Box. Another aim of the case study is to make a contribution to answer the question how knowledge that enhances creative designing can be taught by explicit instructions. For that reason three different types of tasks, an academic task, a best practice example and a real world problem, have been evaluated regarding their practicability in teaching TRIZ-Box.

Keywords: TRIZ-Box, creativity support, design education, case study

1 INTRODUCTION

Creativity is an essential part of innovative product development [1] and there are several methods supporting the creative activities within it. A central principle of creativity methods is to depart from the identified problem by means of abstraction. In TRIZ, the theory of inventive problem solving [2], the problem is formulated by an abstract contradiction that can be solved by at least one of forty inventive principles. Based on these principles the designer shall be enabled to create ideas for specific solutions addressing his actual problem. The method presented in this paper bases on conventional TRIZ. It is called TRIZ-Box [3]. It systematically supports the step of concretizing the abstract inventive principle to a specific technical solution. Its key concept is to connect the inventive principles of TRIZ with artifacts that represent those specific principles in a functional, technical or physical way. The integration of these artifacts into creative group work leads to visual and haptic stimuli and enables the using of analogies to overcome creative design fixation [4].
The study presented in this paper considers the utilization of the TRIZ-Box within three half-day tutorial sessions of an educational product development project. In each session the students were first taught the theory of TRIZ and the way the TRIZ-Box is to be used. In a second step they applied the method to find new solutions to a given product development problem. In a last step the students were asked to select their best solutions and present them to their fellow students. The case study focuses on the research of supporting creativity. For that purpose all 42 participating students have been asked about the quantity and quality of the solutions they generated while applying TRIZ-Box. Another aim of the study is to make a contribution answering the question how knowledge that enhances creative designing can be taught by explicit instructions [5]. For that reason three different types of tasks, an academic task, a best practice example and a real world problem, have been evaluated regarding their practicability in teaching TRIZ-Box.
The paper proceeds as follows. Section 2 gives a brief overview of TRIZ and TRIZ-Box and specifies how these methods support creativity in design. Section 3 points out the challenges in teaching creativity methods with regard to the factors knowledge, motivation and flexibility. Furthermore the deduced consequences for the TRIZ-Box case study are illustrated. In section 4 the results of the case study are presented. The result’s discussion considers both the aspects of creativity support and the aspects of creativity education. Section 5 concludes.

2 BACKGROUND

This section gives a short insight to creativity in design and to TRIZ, the Theory of Inventive Problem Solving. Eckert et al. [6] see the central part of creative thinking in the creation of novel mental structures and the combination of elements of different mental spaces. In this section it is shown how TRIZ and TRIZ-Box support creativity by changing one's perspective (creation of novel mental structures) and giving inspiration (different mental spaces).

2.1 Supporting Creativity by TRIZ

The idea of TRIZ, the theory of inventive problem solving, goes back to Genrich Saulowitsch Altschuller [2]. In the 1950s he analyzed thousands of patents to understand the nature of invention. His research led to the conclusion that every patent describes a novel solution of a problem that can be characterized by a contradiction between two technical parameters (e.g. "weight" vs. "speed"). Altschuller abstracted the problems and the solutions described within the patents and classified them into 39 technical parameters and 40 inventive principles. The relation between a problem (contradiction) and its solution (principle) is represented in Altschuller's contradiction matrix. The contradiction matrix and the inventive principles are the central elements of TRIZ [7].

The application of TRIZ aims the creation of new solution. It is applied in accordance with the following four steps [8]: (1) Problem selection: the central problem is identified and described in an informal way. (2) Problem transformation: the identified problem is abstracted and formulated as a contradiction between two of the 39 technical parameters. (3) Inventive principle selection: by utilization of the contradiction matrix the identified contradiction leads to a selection of promising inventive principles. (4) Solution transformation: the generic inventive principles are transferred to the primary problem.

While step 1 and 3 consider analytical activities that can be supported systematically, step 2 and 4 consider activities that are characterized by a high level of subjectivity and creativity. In step 2 the user is forced to translate his problem to a technical contradiction, this cognitive task is attended to a change of perspective, which is one central condition for creativity. In step 4 the user is confronted with a selection of generic inventive principles his problem might be analogously solved with. Thus, every inventive principle of TRIZ gives inspiration, an even more important element to support creativity.

2.2 Supporting Creativity by TRIZ-Box

TRIZ-Box expands TRIZ by picking up the main idea of the tech-box method [9]. This method originates in the design field and supports creative idea generation by means of analogous reasoning. It offers various technical artifacts as inspirational tool for single users or group brainstorming meetings. Within the tech-box method the artifact selection is intuitive and non-systematic.

The TRIZ-Box method however uses the systematic TRIZ approach in order to restrict the multitude of technical artifacts and to guide users in artifact selection according to their specific problem. All artifacts included in the TRIZ-Box represent one or more TRIZ inventive principles. The actual TRIZ-Box contains several dozens of artifacts. This assures the availability of more than one artifact for each principle. For usability aspects the allocation of artifacts and principles is implemented in a wiki system.

Based on inventive principles identified in step 3 of TRIZ, the TRIZ-Box method offers artifacts in a problem oriented way, i.e. those artifacts, which are connected to the found inventive principles. The examination of the artifacts supports the fourth step of TRIZ, the solution generation. Depending on the artifact selected, all human senses can be stimulated. Not only visual, but also acoustic and haptic effects, capture the attention of the user. The preoccupation with the selected artifacts enhances the comprehension of the inventive principle. Furthermore it supports the formulation of unconscious solution hypotheses thus amending the creative incubation of the solution generation. The use of the selected problem specific artifacts stimulates thoughts and ideas towards the direction of the inventive principles and thus possible new solutions [3].

Within the TRIZ-Box method the purposive application of sensual stimulation using technical artifacts facilitates the solution generation in TRIZ and enhances the creativity support of ideation processes.

3 CREATIVITY IN DESIGN EDUCATION

This section points out the challenges in teaching creativity methods with regard to the three factors knowledge, motivation and flexibility. Furthermore the deduced consequences for the TRIZ-Box case study are illustrated.

3.1 Challenges in Teaching Creativity Methods

Chakrabarti [10] proposes knowledge, motivation and flexibility as the three factors that are essential for creative thinking. These factors are not independent of each other. In education of creativity methods this assumption leads to additional challenges. In direct application of creativity methods in product development the designer has certain knowledge about the product and the problem that is connected to the development. His motivation is grounded in finding solutions to the problem and, if he is familiar with the method, he is able to use the method in a flexible way.

In education of creativity methods the factors knowledge, motivation and flexibility are differently characterized. In the beginning of a creativity method tutorial students normally know neither the method, nor the task their have to solve. The student's motivation strongly depends on the suitability of the task and the demonstrativeness of introducing the method. Even the required flexibility can only be achieved by a well-chosen task and a personal mentoring of the method.

In consequence there are challenges in both introducing the method and choosing an adequate task. As shown in figure 1 the task has to be easy to understand, but must not be trivial. Furthermore the task has to match the size of the student's group. Another challenge lies in the presentation of the creativity method. The procedural steps of the method have to be explained by a demonstrative example. When the students apply the method, the transfer from the example to the task should be supported by mentors.

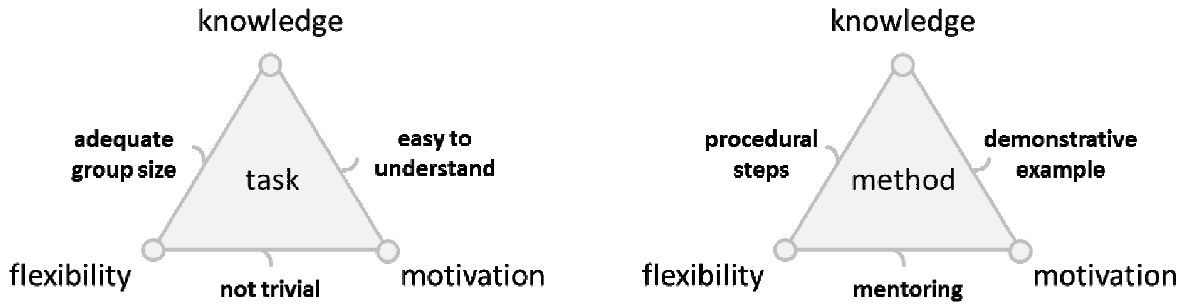

Figure 1. Challenges in the choice of a task and the introduction of a creativity method

3.2 Consequences for TRIZ-Box Case Study

While the aim of the tutorial is to enable the student's competence to apply TRIZ-Box in their own product development project [11], the aim of the case study is to make a contribution answering the question how knowledge that enhances creative designing can be taught by explicit instructions. The TRIZ-Box tutorial starts with a short overview on creativity in design and continues with an introduction of TRIZ and TRIZ-Box. The procedural steps of TRIZ (see section 2.1) are presented and explained by a demonstrative example from medical engineering. Within the tutorial the 42 student of the course are divided in 9 groups with 4-5 students each. An inquiry afterwards confirms that this group size is most suitable applying TRIZ-Box.

The task the students had to solve within two hours was one of the variables of the case study. There are three different tasks assigned: an academic task, a best practice example and a real world problem. The academic task is introduced by Altschuller [12]. It considers the loading of a ship during heavy rain under the condition that no water may enter the storage. The best practice example describes an industrial problem that already is successfully solved by TRIZ. It considers the cutting process of a cohesive compound [13]. The aim is to find easy solutions that guarantee a clean cut surface. The real world problem is part of a product development concerning the improvement of a tow bar for airplanes. This task is characterized by different cases of application and various boundary conditions like interfaces to aircrafts or ground support equipment. In conclusion the three presented tasks strongly differ in their severity level.

4 TRIZ-BOX CASE STUDY

In this section the case study and its results are presented. All 42 students of the product development project “IP 2011” have filled out a questionnaire concerning the TRIZ-Box tutorial. The case study results are divided into two parts. The first part considers the creativity support that the TRIZ-Box method is able to provide. Therefore the students had to evaluate the quality of the solutions they found. The second part addresses the educational achievements of the TRIZ-Box tutorial. As described above all results are analyzed based on the three assigned task.

4.1 Achievements in Creativity Support

There are different approaches to evaluate the level of creativity of a solution. Howard et al. [7], for example, suggest a classification into the following success criteria: (1) Frequency specifies how quickly ideas are being produced, or how many ideas in a given time, (2) Originality describes whether the idea is related to a completely new concept or not and (3) Appropriateness verifies whether the idea is disregarded or is selected for further exploration.

By answering open questions the students confirm that the TRIZ-Box artifacts “are extremely helpful to get away from obvious solutions” and that “the artifacts support lateral thinking”. Nevertheless, the following results show that there are differences in the evaluations of the student’s solutions depending on the assigned task.

The first success criterion considers the quantity of realizable solutions. The highest number of such solutions is generated by the groups that have been confronted with the academic task (7-12 final solutions). The students working with the best practice example developed 7-9 final solutions, and those, who had to solve the real world problem, finally presented 1-4 solutions.

Furthermore the students had to evaluate the originality and the appropriateness of their solutions. The results are presented in figure 2. The left diagram shows the level of originality of the solutions in total and broken down to the different tasks. Thus it appears that the solutions solving the real world problem are more originally than those of the best practice example. One possible explanation could be that, in the case of the best practice example, good solution are already known and realized. An interesting result is revealed by the evaluation of the academic task: The left diagram shows that even a task, which is very easy to understand, must not be trivial. Even an academic task can offer the possibility to generate a high number of novel solutions.

The right hand diagram considers the appropriateness of the generated solutions. Due to a pre-selection, in which the student separated realizable from non-realizable solutions, there are no solutions left that are characterized by a low level of appropriateness. The remaining evaluation indicates a minor advance of the real world problem in comparison to both the academic task and the best practice example. Independent from the task it appears that neither motivation, nor flexibility is the critical factor that delimits creativity in this tutorial, but the lack of knowledge about the task, the student are confronted with.

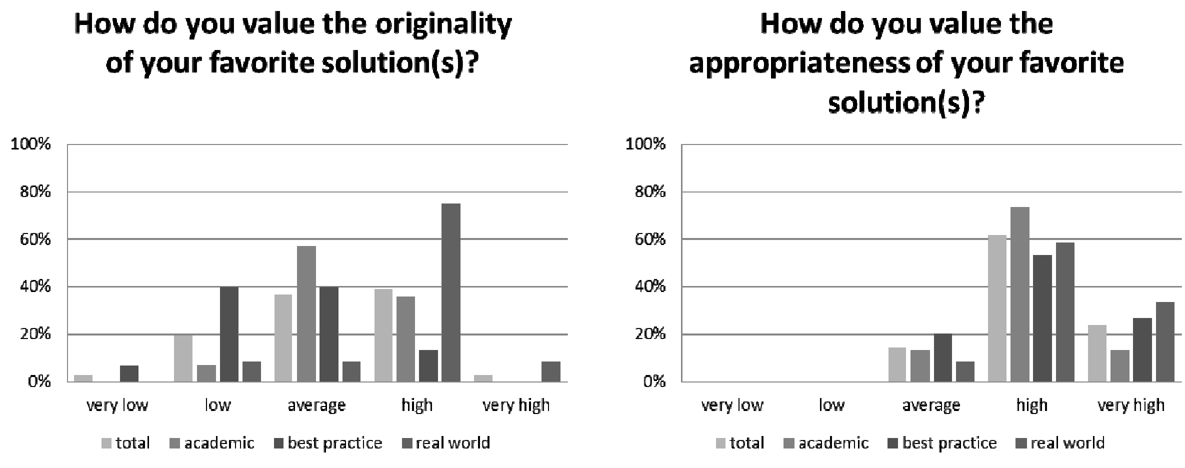

Figure 2. Evaluation of originality (left) and appropriateness (right) of solutions (n=42)

4.2 Achievements in Creativity Education

An important aspect of teaching TRIZ-Box is the mentoring, while the students go through the procedural steps of the method. Especially the transformation of the identified problem to an abstract formulated contradiction between two technical parameters has been identified as a difficult step that needs to be supported by advanced TRIZ users. The students, who had to solve the real world problem, needed additional help to understand the problem and its context. As described in section 2.2 a wiki system is used to support the selection of the TRIZ-Box artifacts. The case study confirms that the wiki system is a helpful tool in TRIZ-Box application. More than 80% of the students agree with this statement. The information provided by the wiki system is directly integrated into the creative discussion of the student's group. Thus, the creative process is not interrupted.

The student's majority (93%) never applied TRIZ-Box before. In the end of the tutorial the students evaluated their level of expertise in TRIZ-Box. The results are shown in the left diagram of figure 3. More than 25% of the students stated to comprehend the meaning and the procedure of TRIZ-Box, nearly 70% felt confident to apply the method to solve future problems and a few students even mastered the subject matter. In comparison of the three different tasks it appears that the best practice example led to less success than the academic task or the real world problem. An explanation could be that the students compare their solutions to those described in the best practice example. In the case of a discrepancy the students may suggest their incorrect application of the method. Nevertheless, the students also identified risks in choosing the academic task or the real world problem. The open question on how suitable their task is was answered with statements like: "when carrying out an easy task, one tends towards not applying the method" (academic task) or "understanding the problem had cost a lot of time" (real world problem).

Another question considers the student's motivation to apply TRIZ-Box in their own product development project. The diagram on the right shows that more than 75% of the students tend to a future TRIZ-Box application. It seems that those students who were assigned by the academic task were less skeptical of the method's benefits than the other ones.

Figure 3. Evaluation of TRIZ-Box abilities (left) and application motivation (right) (n=42)

5 CONCLUSION

The case study presented in this paper indicates that there are interdependencies between the task assigned within an educational tutorial and the creativity support a method is able to provide. Using the example of the TRIZ-Box tutorial it was shown that for educational purposes a best practice example is less suitable to support creativity than an academic task or a real world problem. Nevertheless a best practice example can be used as a demonstrative and motivating example introducing the procedural steps of a creativity method. Academic tasks should be assigned to teach a general application of the method. This type of task may lead to a high number of solutions, characterized by an average level of originality and appropriateness. Real world problems additional impart knowledge about the benefits and the limits of a creativity method. Within the case study methodical solving of real world problems resulted in a small number of very creative solutions that may be a promising origin for innovative products.

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