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Burcu Taşkın

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A Comparison of Two Innovation Tools: Application on Smart Kitchen Design

Burcu Taşkın[1], Nuri Başoğlu[1], Tuğrul Daim[2]
[1] Department of Industrial Design, Izmir Institute of Technology, Urla, Izmir, Turkey
[2] Department of Engineering and Technology Management, Portland State University, Portland, OR, USA

***Abstract*--The process is one of the significant issues of companies in innovative product design. The designers and the management deal with producing high quality products with the creativity in a short-term period. The researchers developed techniques to solve that problem as TRIZ. The TRIZ-based techniques aim to recover the gaps of the creative innovation to solve specific problems of technical products and technologies. However, the traditional innovation techniques are still preferred for the design process.**

This study conducted a comparative research on outcomes regarding the process of two design groups. The assignment is given to ten design students to identify the design requirements of smart kitchen design that answers the specific problem and to propose a product through needs and demands. First group with five students applied TRIZ-based techniques, while the other five students applied one of another innovation techniques.

In this study the outcomes of the group design of smart kitchen is discussed to compare the application of the process and quality of the products.

I. Introduction

Designing new innovative product has strongly relation with creativity. Besides the process is the significant issue that affects the management and design fields. The industries tend to design the new products in short term period. The researchers developed many methods in order to improve the innovative solutions.

Besides the innovative solutions the designer thinks the end-user in the context of functionality, economics, ergonomics, aesthetics etc. The creative design should answer the needs and demands of end-user. The demands and well-organized problem definition is the starting point of the designers.

The research based on creativity issue on innovative new product to solve a design problem that is necessarily important in design process. The study aims to understand the affect of methods in design process and quality of the design solution for a limited problem.

The research questions the affects of the innovation techniques on design process from the designers' and professionals' perspectives, and differentiation of the groups' approaches that are applied different innovation techniques on a specific design problem.

The results of the assignment will be discussed in terms of design process and quality of the project solutions.

II. Literature Review

A. Creativity in Design Process and Problem Solving

Creativity is discussed in many disciplines and increasing in the design field. Besides many definitions of creativity, the common explanation in the Webster's dictionary is "the ability or power to create-to bring into existence, to invest with a new form, to produce through imaginative skill, to make or bring into existence something new" [1].

According to Roger von Oech "creative thinking involves imagining familiar things in a new light, digging below the surface to find previously undetected patterns, and finding connections among unrelated phenomena" [2].

The creativity is interrelated with new product development through alternating the problem solutions. The fundamental factors of personal creativity are relevant with the person's "intelligence, knowledge, thinking styles, personality, motivation, and environmental context" [3]. Psychologist Sternberg's definition of creativity is illustrated as:

$$C = f(I, K, TS, P, M, E) \quad (1)$$

(1) "Where C is creativity, I is intelligence, K is knowledge, TS is thinking styles, P is personality, M is motivation, and E is environmental context" [4].

Relatively Sternberg's research, Yan Li [5] developed creativity model for product innovation. The qualitatively expression of their design creativity definition is:

$$DC = f(K, I, TS, DM, ST, U) \quad (2)$$

(2) "Where, DC is design creativity in product innovation, K is knowledge, I is information, TS is thinking styles, DM is design methods and ST is computer supporting tools, U is uncontrolled and unchanged factor in a short time, could be uncertainties, such as environment and culture" [5].

Approaches on creativity depend on the fields and professions for problem solving. A research on problem solving that comparing a scientist and a designer claims that; "scientists use problem-focused strategies for problem solving, whereas designers focus on the solution to a given problem" [6]. Thus the scientist prefers analysis while designers prefer synthesis for the problem solving.

"The more time a subject spent in defining and understanding the problem, and consequently using their own

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frame of reference in forming conceptual structures, the better able he/she was to achieve a creative result" [7]. Saving time for design process in creativity process can be possible with defining and framing the design problem. Another research suggests, "creativity in the design process can validly be compared to such bursts of development" [8].

The creativity and well-structured problem definition are necessarily important for problem solving for innovative new products.

B. Innovation in New Product Development

In literature, the studies increase in the field of innovation. One of the definition of innovation as 'any thought, behavior or thing that is new because it is qualitatively different from existing forms and is the basis of cultural change' [9].

Innovations supply 'newness' or 'differences' that include value providing in products, processes, technologies, methods and business models from the elements of the new or same ones that earlier made. Innovations are creations that are often built by the occurrence of one or more events with 'small / low success probabilities' that may require 'high problem resolution' and show 'possibility effect of a particular solution or deliverable in the native state of occurrence of the events in the product, process, technology, method or business model' and hence can be called as 'innovation events' [10].

Previous researches emphasize the importance of innovation for problem solving. The researches point not only the economic value of design and efficiency, but also design methodology in new product development (NPD) process. Therefore design driven NPD provides competitive advantage, evolves technical performance and reduces production costs [11].

Innovation proposes new products and services including transformed ideas that are precipitated by creativity [12]. Creative design is core of product innovation, which is a key factor of enterprise innovation [13]. Furthermore, effective innovation process with a structured design method pushes business forward for NPD [14].

Some internal factors such as new technologies, investing on research and development activities, cause competitiveness between firms on innovation and NPD process. Customer and market specifications [15], and the policy of the firm for future business [16] lead innovation as well as the suppliers' competition requirement that is formed by the technological improvement.

Innovation does not always connote utilization of the state of the art technology. Conversely, it is less a question of technology, and more a way of thinking and finding creative solutions within the company [17]. Within this scope, Innovation Management Techniques (IMTs) can be considered as stream of tools, techniques and methodologies that supplies a systematic way to the companies for adaptation of conditions and meeting market challenges [18].

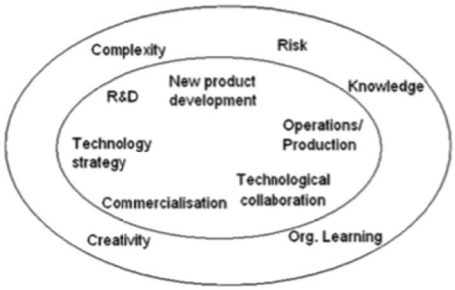

Fig. 1. Management of technological innovation: a holistic approach

Fig. 1 "proposes a holistic model that includes six specific areas in the management of technology innovation, which is complex and risky: R&D, new product development, commercialization of innovation, operations and production, technological collaboration and technology strategy" [19].

Innovation process and innovation management are significant for the dimension of innovation. The innovation process also includes designing with a well-structured problem definition.

Through innovation, companies are able to gain more continuous influence. Therefore has innovation management a high priority for the companies. [20]

Regarding this fact, innovation is strategically a fundamental element for the global economy to expand the benefit of individual companies and gives a chance to prove themselves to reach more stakeholder and achievement [21]. Innovation also comprise, that the use of the technologies can be improved according to the market and thus a higher opportunity to get more satisfied customers. By concentrating more on value creation, the company is trying to adapt itself more quickly and more effectively to the benefit of valuable customers [22].

Innovation management is:

- Preconditions' creation to support creativity;
- A process to encourage knowledge application [20].

The designers deal with the NPD in terms of innovation and design method to answer the competitiveness of firm. The value creation through end-user is one of the design issues. The new product development process and management, with effective knowledge structure that incorporates the product design process are essential aspects for the success of new products [23] [24].

Product design process, which consists "integrated efforts, including generating ideas, developing concepts, modifying details, and evaluating proper solutions", is fundamental for new product development [25].

C. TRIZ as a Design Method in New Product Development

One methodology cannot be correlated on a specific business problem of a firm because of the complexity of IMTs. In spite of some principles of good applications exist, there is no a single ideal model for innovation management

[17].

Table 1 summarizes the ten IMT typologies and their associated methodologies/tools [17].

TABLE 1. IMT TYPOLOGIES AND ASSOCIATED METHODOLOGIES

IMT typologies	Methodologies and tools
Knowledge management tools	Knowledge audits Knowledge mapping Document Management IPR Management
Market intelligence techniques	Technology Watch/ Technology Search[1][SEP] Patents Analysis[1][SEP] Business Intelligence[1][SEP]
Cooperative and networking tools	CRM: Customer relationship management Geo-marketing Groupware[1][SEP]
Human resources management techniques	Team-building Supply Chain Management Industrial Clustering Teleworking
Interface management approaches	Corporate intranets On-line recruitment e-Learning[1][SEP]
Creativity development techniques	Competence Management R&D - Marketing Interface Management Concurrent Engineering Brainstorming Lateral Thinking[1][SEP]
Process improvement techniques	TRIZ Scamper Method Mind Mapping[1][SEP] Benchmarking[1][SEP]
Innovation project management techniques	Workflow[1][SEP] Business process re-engineering Just in Time
Design and product development management tools	Project management Project appraisal Project portfolio management CAD systems
Business creation tools	Rapid Prototyping[1][SEP] Usability approaches[1][SEP] Quality Function Deployment Value analysis Business Simulation[1][SEP] Business Plan[1][SEP] Spin-off from research to market

An innovation management technique cannot be noted all alone. Measurement of the profitability of one IMT for specific business challenge is common in combination with other IMTs that is adapted to varying degrees for each specific case.

The company realizes benefit in regard to an integration of IMTs. The mix of two elements and the firm confirm an effective outcome. An understanding on successful relation between IMT and the company that supports the definition of clear aims and the criteria, which can be formed regarding the survival, growth, new product introduction, competitiveness, etc. The criteria are needed to know when those goals will be successful [23].

Design methods are essential elements for creative design. The designers' creativity can be positively affected with a well-structured design methodology [5]. To demonstrate correctly defined and presented the design problems are important to develop strategies properly. Moreover, the design methods with high-qualified representation and conceptual construction raise the efficiency of the result with half performance of the designers. For instance function-behavior-structure, TRIZ are the methods that help the designers to save their time with half exertion.

The creative problem solving, which refers to the evolutionary principles of the technical systems, implies the research object, which are used by some researchers as a methodology to support the creative and innovation process. Altshuller's theory claims that the inventive problem solution (TRIZ) [26] is based on direct analytical inventions that are registered in patents and other sources. Which aim to create a so-called pattern of the invention in the technological development.

The TRIZ Concept based on a hypothesis, which believes that the basis of creative innovations is used by universal principles of creativity. This process should affect the understanding of people to anticipate the creativity process.

As a comparison to Altshuller, Savransky prescribes the TRIZ as a "human-oriented knowledge-based systematic methodology of inventive problem solving" [27]. Similar to this idea, Souchkov [28] defines TRIZ as a three pillar based research:

1- analytical logic
2- knowledge based philosophy
3- a systematic way of thinking

These three leading conclusions of more than 65-year research offer creative solution of problems in industry and sciences. Additionally it offers systematic innovation to accelerate the ways of creative problem solving, which covers all possibilities of solution to be innovative in inventing problem solving [29][30].

The Figure [31] below shows the TRIZ process in a graphic.

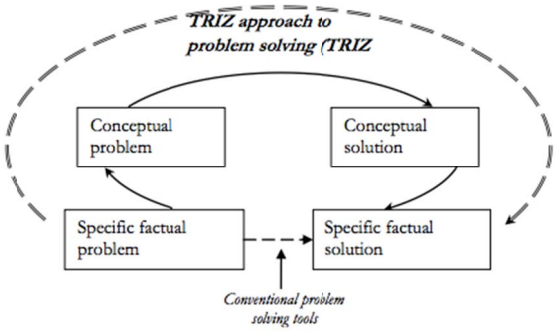

Fig. 2. TRIZ systematic approach to problem solving

Fig. 2 demonstrates us how the specific problem turns into a general TRIZ problem, where it can be applied to the specific problem again within a defining of the TRIZ solution.

III. METHODOLOGY

A. Research Method:

The research based on three phases (Fig. 3). In the first phase, the professionals are involved into focus group to prepare assignment for second phase. The third phase is to discuss, evaluate and compare the design process of two problem-solving.

TABLE 2. APPLICATION PHASES AND GROUP INFORMATION

Phases	Groups	Participants	Objectives
P1	Focus Group	10 professionals (2 computer engineers, 2 mechanical engineers, 2 city planner 2 architect, 2 designer)	To prepare a detailed assignment with a specific target and design problem.
P2	*Group A (Chosen by the students who do not know TRIZ)	6 Students (2 Architects, 2 computer engineers, 2 mechanical engineers)	Free to use any innovation method
	*Group B	6 Students (2 Architects, 2 computer engineers, 2 mechanical engineers)	Applied TRIZ based innovation method
P3	*Professionals Group A, Group B	3 professionals, Group A and B	Self assessment, Grading the assignments

* The student groups and professional industrial designers are selected from the Izmir Institute of Technology with an announcement at campus.

The methodology used to achieve the objective of the descriptive experiment was organized in the following steps:

- *The Design Assignment*

Preparing a design problem with focus group for assignment that will apply to two groups.

The focus group prepared design assignment regarding to be challenging, realistic, feasible in the time, appropriate for experimental process, and within the sphere of knowledge of the researchers. The assignment was to create a conceptual solution for a smart kitchen to working people in Izmir, Turkey. The problems defined through the working people and their needs and demands for smart kitchen. The specifications of problem require the designers concerning the integration of a variety of technology, creativity, engineering, aesthetics and innovation aspects. The information they need was prepared on information sheets, with one specific topic on each sheet. Designers were free to ask anything to researchers during the design experiment process.

The design problem is limited with the target, space, and function.

- *The Design Assignment or Problem*

To produce a smart kitchen for working people that have time limitation for preparing food.

- *Division of the Groups*

Division of the groups by application of innovation technique as: TRIZ based technique and any design technique that used in product innovation. Group A: not limited with any technique for problem solving, Group B: TRIZ based techniques explained to the group to use for the problem solving. The designers were asked to develop a solution by the help of sketch or text. The groups are not limited with time and number of design solution.

- *The Experimental Procedure*

Before the experiment the groups meet and took their time for knowing each other. The experimental procedure and participant rights were explained briefly. The information they need was prepared on information sheets, with the template (Fig. 3) for selected activities and functions for assignment. Designers were free to ask anything to researchers during the experiment process. Group A directly started the assignment with template on given problem. Group B took a lecture on TRIZ based innovation technique for structuring the problem abstract. The lecture with 25 slights took 40 minutes to explain TRIZ and samples.

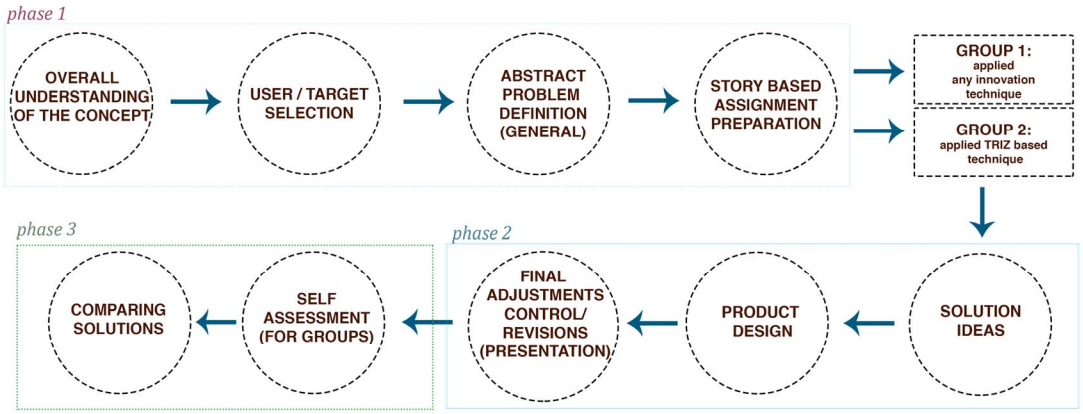

Fig. 3. Research Flow

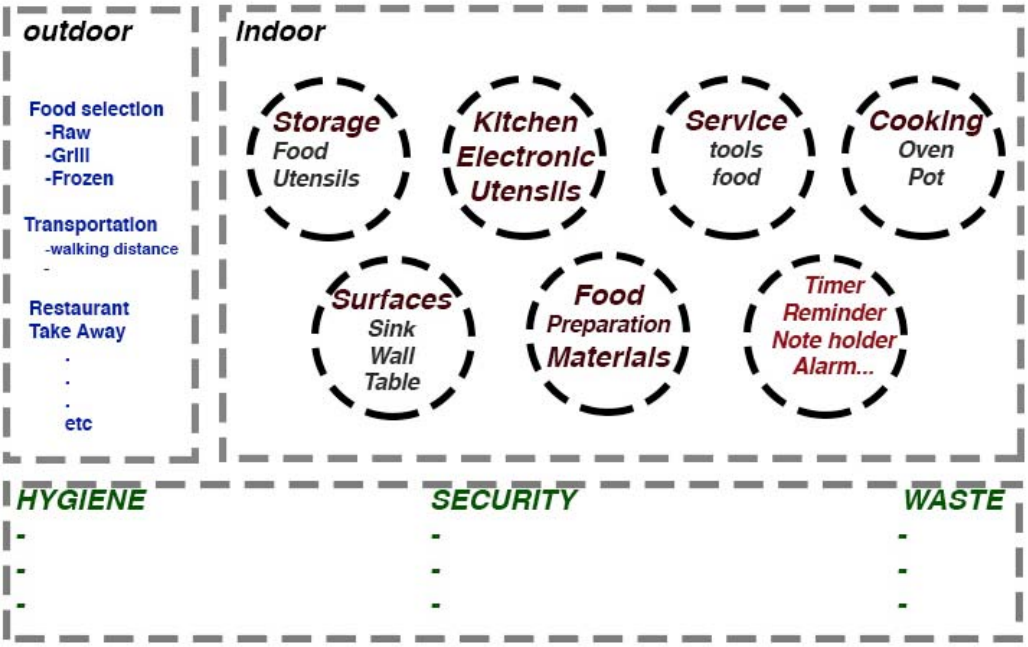

Fig. 4. Template for Assignment

- *Data Analysis:* Self Assessment and Professional Grading

To understand the performance of the groups through methods two questionnaires are prepared for self-assessment and grading by professionals. Compared the answers through methods and outcomes of the designs. The structured interview phase performed after the assignment part.

For reducing complex processes of design activity and simplifying design objects the professional industrial designers grade the outcomes of the assignment regarding their solution, design requirements, design process, and feasibility.

The self-assessment is conducted to understand the methods for problem solving experience of the participants. The interview applied to get feedback to describe the application of methods in design process.

IV. Results & Findings

A. *Phase 1 Results:*

The focus group defined a problem on innovative design with a specific target. The assignment is detailed as listed below:

- The groups should solve the problem in a short time period,
- The design problem should be chosen in an area that is not common in existing market or everyday life to make the groups feel free to be innovative and creative,
- The challenges of the assignment should be understood easily,
- The target should be chosen as the groups can imagine easily for empathetic thinking.

Focus group defined the assignment considering the details as:

- Working people is the target which the groups can easily identify the troubles in everyday life,
- The time is essential for working people,
- The common problem is time,
- Mainly working people tend to prefer smart kitchen,
- The food should be healthy because the nutrition is a basic need.

The listed issues are guided the story based assignment that is avoided not to limit the creativity of the student groups.

B. *Phase 2 Results:*

Group A took the assignment and start discussions on the assignment by creating mind map, brainstorming on the given problem as the steps below:

- Different general ideas to alternate the solutions and the existence of decomposition.
- The main ideas to solve the problem, the use of analogy. The development of ideas.
- The development of ideas and the initial concept.
- Optimizing the process of ideas and sketching concepts. Evaluation of some ideas.
- Describing again the solution, evaluating and iterated for apparent optimization

The major solutions are to improve a service system for ordering food from restaurants, and a technologic kitchen that could cook by self.

Group B- Application of TRIZ Method

Problem definition is rewritten to narrow the scope: Smart

kitchen design to save time and energy in a healthy way for working people between 20-40 years old.

They organized the structure of the method as: problem abstraction, conceptual problem, and conceptual solution.

The problem abstracts: The template used for abstract the problem as: Time-food, time-preparation, and time-service relations.

TABLE 3. CONCEPTUALIZATION OF PROBLEM AND SOLUTION

The conceptual problems are:	The conceptual solutions are:
- Control of the expiration date of food	- Date alert that controls the toxin of food
- Heating the food on time	- Food heating unit to reduce heating time that the people mostly waste the time

Solution: The combination of the conceptual solutions that offers heating-cooling system, and date alert for rotten food.

C. *Phase 3 Results:*

Three professional industrial designers graded the design solutions through; reliability, feasibility, technology, problem solving design process design quality and function between 1 - 5 score. The average of the each grade is taken (Table 2).

The results show the TRIZ construct the problem and create solution systematically. The efficiency raise and the process reduced for time while the solutions are strong.

TABLE 4. GRADES OF THE GROUPS*

	Group A	Group B
Reliability of Product	3	5
Feasibility of Product with Today's Technology	2	5
Problem solving	2	5
Design Process (Productivity)	2	5
Design Quality And Creativity	2	4
Functional Value of Solution	4	4

** The grades are scored out of 5. For the Group A the technologic kitchen design solution is calculated.*

The self-assessment results are coded as comparing the advantageous method with the participants that attended to the experiment (Table 5). They are asked to grade the each question over 10.

TABLE 5. SELF-ASSESSMENT RESULTS*

Satisfaction On:	Group A	GroupB
Achievement	5	8
Productivity	5	7
Sufficiency	4	5
Creativity	6	7
Time management	4	8

** The grades are scored out of 10.*

The application of TRIZ satisfied the group more than the other group in terms of achievement, productivity, sufficiency and time management except creativity. The time management is the significant difference that is observed.

V. DISCUSSION

The food culture and daily life activities are predominant through cultural issues. The cultural domains and life styles are the significant factor through needs and demands. In additional, the kitchen where the people create private space, involve lots of issues concerning to cultures, income levels, social statuses, life styles, etc. Thus, the study focus on constellation related with these issues to discuss the major problems. The results can be variable for different culture.

Time limitation for TRIZ lecture and the heterogeneous background of the students through their knowledge and creativity levels are related with the results.

The Group A tried to answer the problems for each function. The template usage is weak and they do not organize their methods properly. They tried different method until they satisfied with the idea. They could not improved one strong idea in 5 hours long. The main answers of them discussed as:

- The first solution is to improve the existing system, which do not answer the problem correctly.
- Second solution's technology does not exist for today.

The Group B succeeds for the TRIZ application for problem-solving in a systematical way. Even the TRIZ lecture was not applied comprehensively; the results show the positive effect on time management and design process.

The self-assessment depends on personal preferences that can be variable. The self-assessment results of this study show that the TRIZ techniques are beneficial to designers for design process.

One of the problems in innovation process depends on lack of knowledge on methodologies. The methodology guides the process to success in the innovation field. The study claims that raising the knowledge on TRIZ application on design improve the achievement of goals and management on innovation. The time management of Group A was not systematic because the experience level on any structured methodology that they attended before. The participants note that the effectiveness of the integrated technique as TRIZ in innovative design considerable because of its systematic approach that decrease time while developing the creativity, achievement, sufficiency, productivity.

VI. CONCLUSION

Creativity and innovation are the fundamental issues in the new product design for both academics and practitioners.

The well-structured problem definition and the design methods are variable for each field.

Even developing systemic methods based on TRIZ to help designer form systemic creative thinking, it is not commonly used by designers. The results show the design methods as TRIZ is significantly reduce the time period of design process and decrease the quality of design requirements. The designers satisfied with TRIZ application during the experiment regarding achievement, productivity, sufficiency and time management. TRIZ based systems on engineering and management increasingly developed. In this context, the research supports that the TRIZ based designs create significant time saving and raising the design quality.

The problem definition is the important issue for finding the solution. The TRIZ technique helped the design process in terms of reorganizing the problem definition.

In more detailed problem definition, the use of innovation management tools and techniques are considerable for the systematization of the design process.

For the further researches the innovation methods in design, which is complex process, could be varied and applied to different groups and fields.

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