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Article · January 2011

DOI: 10.1115/DETC2011-48256

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Proceedings of the ASME 2011 International Design Engineering Technical Conferences & Computers and Information in Engineering Conference
IDETC/CIE 2011
August 28 – 31, 2011, Washington, DC, USA

DETC2011-021711

A STUDY OF THE EFFECTIVENESS OF EMPATHIC EXPERIENCE DESIGN AS A CREATIVITY TECHNIQUE

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ABSTRACT

The need for innovation in product design is an ongoing challenge. Many methods have been proposed to create more innovative products and to better identify customer needs. In this study we introduce an Empathic Experience Design (EED) method to be used just prior to concept generation to help create more innovative concepts. The EED method exposes the designer to empathic experiences, which are designed to help the designer empathize with customers who use the product under a variety of non-ideal conditions. Separate experiments were conducted at two universities, in which students were asked to develop concepts for a next-generation alarm clock. Subject and control experiments were designed and implemented, and the resulting concepts were analyzed to determine the originality and technical quality of each concept. The subject group concepts, which were developed after participating in the empathic experiences, were compared with the control group concepts, which were developed without empathic experiences. At each university, the subject group concepts demonstrated significantly higher originality, relative to the control group concepts, without any sacrifice in technical quality.

1. INTRODUCTION

Creativity is often considered to be a precursor to innovation and the development of innovative ideas in product design. Most work on creativity has focused on the development of methods for thinking outside of the proverbial box. Methods consist of formally structured methods for group ideation such as brainstorming [1], 6-3-5 [2] and C sketch [3] as well as methods that are meant to help trigger new ideas through analogies such as biomimetic design [4] and design by analogy [5]. McKoy and colleagues compared traditional textual based ideation methods with drawing based methods to determine which idea generation medium leads to the best concepts. They determined that graphical representation and sketching are the most effective for concept generation [6].

Effective concept generation requires a thorough understanding of customer needs. One good way of studying such needs is through user-centered methods for design and concept generation. For example, Maier and Fadel [7] focus on affordances, which describe and explain the relationships between users and designed artifacts. Empathic design helps a designer explore those relationships by collecting user needs from observations and interviews in the customer's own environment [8]. Leonard and Rayport [8] report that a group of young designers at Interval Research Corporation in Palo Alto, California, were outfitted with fogged glasses, gloves, and weights on their arms and legs so they could feel what it would be like for the very elderly to operate prototype physical controls. These simulated functional limitations allowed the young researchers to apply their knowledge of design within constraints that they could not otherwise personally experience. In a similar setting, Ford engineers developed a simulation suit with goggles, ear plugs, thick gloves, motion restrictors, and arm and leg weights and to help their young engineers understand the challenges faced by older drivers [9]. IDEO designers use similar empathy tools to better understand the needs of users in particular contexts [10]. A prominent technique is bodystorming in which participants "act out current behavior/usage patterns and see how they might be altered [11]." These examples suggest that simulated empathic user experiences could result in better designs, but the link has not been proven.

Another suggested approach to innovative design is to use expert users to determine user needs. One type of expert user is the lead user [12], who pushes a product to its limits, but lead users can be hard to identify or access for all design scenarios. It has been suggested that lead users are not the only type of expert users; disabled users and even ordinary users in an extraordinary situation could also be considered expert users. Hannukainen and Hölttä-Otto [13] found that the needs of extraordinary users correlate well with those of ordinary users when placed in special situations. In their study, extraordinary users, namely blind and deaf users, were compared with ordinary users placed in simulated situations, including dark and/or noisy environments. When the ordinary users were placed in a special or unique situation, they identified the types of latent needs previously articulated by the extraordinary users.

In a follow-up study by Lin and Seepersad [14], results of interviews with ordinary customers were compared with the results of empathic interviews, in which ordinary users were asked to assemble tents in a dark room with oven mitts on their hands. This setting was developed to simulate the conditions of assembling the tent in the dark and in cold weather or with limited vision or dexterity. The empathic interviews were found to have a positive effect on the discovery of latent needs.

In this research, we build upon the work of Hannukainen and Hölttä-Otto [13] and Lin and Seepersad [14] to establish and experimentally evaluate the Empathic Experience Design (EED) Method. EED is a structured conceptual design methodology that is intended to stimulate innovation during concept generation activities by engaging designers in empathic experiences with a prototype product to be redesigned. Empathic experiences are designed to help a designer empathize with customers under a variety of conditions, including non-ideal physical usage environments (e.g., noise or moisture) or strenuous user-product interactions, including physical, cognitive, or sensory-related situational disabilities.

In this paper, the EED method will be described and its effects on design creativity will be experimentally evaluated. Experiments involve evaluating and comparing the originality and quality of concepts generated by a subject group of participants who utilized the EED method and a control group who did not use it for identical design problems. The EED method and the experiments are described in the next section, followed by a discussion of the results.

2. RESEARCH APPROACH

The effectiveness of the EED method was evaluated with separate experiments at the University of Massachusetts Dartmouth (UMD) and The University of Texas at Austin (UT Austin). At each university, subject groups of senior-level mechanical engineering students were tasked with implementing the EED method on a specific design problem. Control groups of senior-level mechanical engineering students solved the design problem without the EED method. Resulting concepts were evaluated with a set of originality and quality metrics. The EED method and the experimental procedure are described in Section 2.1, followed by the metrics for measuring originality and quality in Section 2.2.

2.1 Empathic Experience Design Method and Experimental Procedure

As shown in Figure 1, the EED method consists of a series of five steps. EED experiments were designed and implemented by following the five steps sequentially.

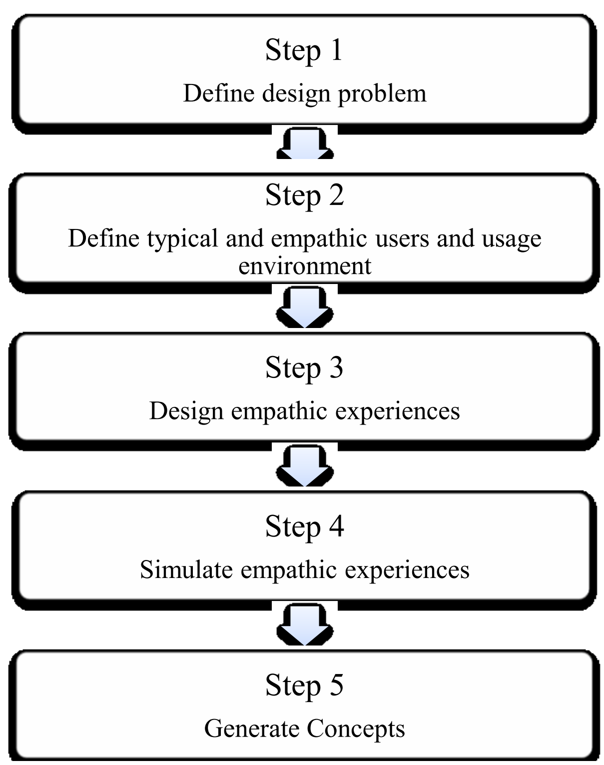

Figure 1. FIVE STEPS OF THE EED METHOD

The first step of the method was to define the design problem. For this study, participants were asked to design a next-generation alarm clock to be sold in the contemporary marketplace. The motivating product was carefully selected. As shown in Table 1, a list of screening requirements was developed. Alarm clocks were chosen for the motivating redesign example because they meet all of the criteria in Table 1, and their most important features typically involve interaction with the user. It was hypothesized that empathic experiences that limit vision, hearing, or touch could be used to stimulate innovative solutions. Also, although innovative alarm clocks have been invented (e.g., pillows that wake users with increasingly bright lights embedded in them), they are not widely available in the marketplace and represent known opportunities for interaction-based improvements to the sample products. Two very basic alarm clocks were purchased for use as prototypes: a digital and an analog model, both with only basic functionality (time display, alarm settings, and alarm on/off toggle), as shown in Figure 2.

Table 1: Product Selection Criteria

- Mechanically or electro-mechanically based
- Medium to light complexity
- Familiar to a wide range of participants
- Amenable to interaction-based improvements
- Experimental conditions capable of leading to interaction improvements
- Low cost

Figure 2. ALARM CLOCKS USED IN EXPERIMENTS [15]

The second step was to define typical and empathic users and usage environments. When defining empathic users and usage environments, we adopted a lead user perspective to identify conditions that challenge the capabilities of the product and/or the user. For this product, challenging conditions include visual impairments or dark rooms that inhibit the user's ability to see, hearing impairments or deep sleeping conditions that inhibit a user's ability to respond to sound, and limited dexterity in the fingers which could be induced by arthritis or sleep-induced lack of coordination.

The third step was to design the empathic experiences that help designers simulate these challenging conditions. Visual impairment due to darkness was simulated with the use of a blindfold; earplugs and headphones were used to limit hearing, which could be caused by deep sleep; and oven mitts were worn to simulate limited dexterity caused by sleep-induced lack of coordination. The empathic devices are pictured in Figure 3.


Figure 3. EMPATHIC DEVICES USED IN EXPERIMENTS [15]

In the fourth step of the EED, participants were encouraged to interact with the alarm clocks for as long as twenty minutes and to engage in discussions about the alarm clocks. For the purposes of this study, students at each university were divided into two groups for a subject-control experiment. Participants in the subject groups were encouraged to try each of the empathic devices in Figure 3. Participants in control groups were asked to simply interact with the alarm clocks without restrictions, and the empathic devices were not made available to them.

In the fifth and final stage of the EED method, participants were asked to generate concepts for the next-generation alarm clock. The concept generation method selected for this study was a modified 6-3-5 method [2]. Students were divided into groups of either six or four, depending on the total number of participants for each experiment. Students were given 15 minutes to develop three concepts each. After the initial 15 minutes had passed and each student completed their three initial concepts, the concepts were rotated clockwise around the table and each student was given six minutes to modify the new concepts in front of them. This process continued until the concepts were returned to the original designer. Control and subject group participants were segregated into separate 6-3-5 sessions at each university.

Participants included a total of 46 students at UMD, divided into 28 control group participants and 18 subject group participants. A total of 112 students participated at UT Austin, including 54 in the subject group and 58 in the control group. All participants were senior-level mechanical engineering students. At UMD, the students participated in a class exercise as part of a senior level design class. Attendance was voluntary. At UT Austin, students were offered extra credit as an incentive for participation. Alternative means of earning extra credit were also offered to ensure that participation was completely voluntary.

2.2 Originality and Quality Metrics for Evaluating Concepts

To evaluate the effectiveness of the proposed EED method, the level of originality of the resulting concepts is measured, along with their quality (or technical feasibility). Measuring both originality and feasibility allows the researchers to investigate whether the EED method leads to more creative concept generation, and if so, whether that creativity is accompanied by a change in technical feasibility.

Originality Metric: Originality was measured at the feature level. A value was assigned to each feature from the five-point scale defined in Table 2. Features were defined according to Table 3. A list of standard implementations of each feature was compiled by examining alarm clocks found at common retail and online stores, namely Target, Walmart and Amazon.com. For each feature, originality was evaluated relative to those lists of standard implementations. After all of the features were evaluated for a concept, the maximum feature-level score was identified and assigned to each concept as its overall originality score. The researchers found that averaging the feature-level originality scores provided a less reliable indication of the originality of the concept because many innovative concepts were distinguished by only one (or a few) original features.

The five-point scale in Table 2 is derived from an eleven-point scale used by Charyton *et al.* [16] for measuring originality and illustrated in Table 4. Although the originality metric used by Charyton *et al.* utilized an eleven-point scale, repeatability studies performed by the authors and other researchers indicate that more repeatable results are obtained from scales with fewer intervals [17, 18]. The researchers found it much less difficult to distinguish between the terms in the five-point scale, versus the eleven-point scale, contributing to its improved repeatability. Also, the five-point scale aligns with commonly applied five-point Likert scales, and it is one of the most recommended scales for use in rating systems [17].

Some researchers use a novelty metric, proposed by Shah *et al.* [19], to evaluate similar aspects of individual concepts. Shah *et al.*'s novelty metric is designed to compare each concept to a set (or universe) of predefined solutions or to other concepts generated by the same experiments. Unlike the novelty metric, the originality metric used in this study provides an explicit five-point scale (Table 2) for rating each feature.

Table 2. FIVE-POINT ORIGINALITY METRIC

Score	Description
0	Common
2.5	Somewhat interesting
5	Interesting
7.5	Very interesting
10	Innovative

Table 3. BASIC AND ADDITIONAL FEATURES OF AN ALARM CLOCK

Basic Features	Additional Features
Mode of alarm	Music
Display type	Alternative use
Information shown	Shape/Layout
Mode of input	
Snooze	
Energy source	

Table 4. ELEVEN-POINT ORIGINALITY METRIC

Score	Description	Score	Description
0	Dull	6	Insightful
1	Common	7	Exceptional
2	Somewhat interesting	8	Valuable to the field
3	Interesting	9	Innovative
4	Very interesting	10	Genius
5	Unique and different		

Quality Metric: To evaluate whether the concepts were not only original but also technically feasible to design and produce, a quality metric developed by Linsey [20], based on a modified version of a metric provided by Shah *et al.* [19], was applied to each concept at the feature level. Accordingly, the evaluator followed the flowchart shown in Figure 4 to reach the appropriate quality score for each feature in each alarm clock concept.

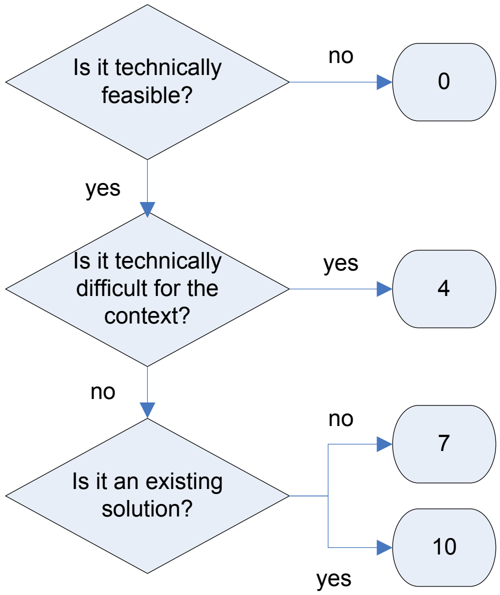

Figure 4. MODIFIED 4-SCALE QUALITY METRIC [19]

Inter-rater Reliability. Inter-rater reliability was assessed with two separate tests. The first test focused on assessing the suitability of the five-point originality metric. Twenty-seven subjects used the five-point originality metric to evaluate ten different products at UMD. No significant differences in originality ratings were found for 80% of the products ($p>0.4$). Marginally significant differences ($p = 0.05$) were found for the remaining two products. This study showed that the five-point originality metric yielded consistent results across a relatively large set of examiners.

The second test focused on assessing the inter-rater reliability of the researchers at the two universities (UMD and UT Austin). The first two authors (both graduate research assistants) trained themselves on the originality metrics by evaluating a randomly selected set of ten concepts from the study. After discussing the results, the authors repeated the exercise for another set of ten concepts. For the second set of concepts, originality scores provided by each evaluator were compared using a weighted version of Cohen's Kappa [21]. The inter-rater reliability was found to be very good for originality, with a weighted Kappa value of 0.67. Similar levels of inter-rater reliability were achieved between the graduate student researchers and professors at each university. Previous inter-rater reliability tests for quality also earned high weighted Kappa values greater than 0.9.

3. EXAMPLE ANALYSIS OF CONCEPTS

To illustrate how the metrics were evaluated, a sample analysis is provided in this section for two concepts: one control group concept and one subject group concept.

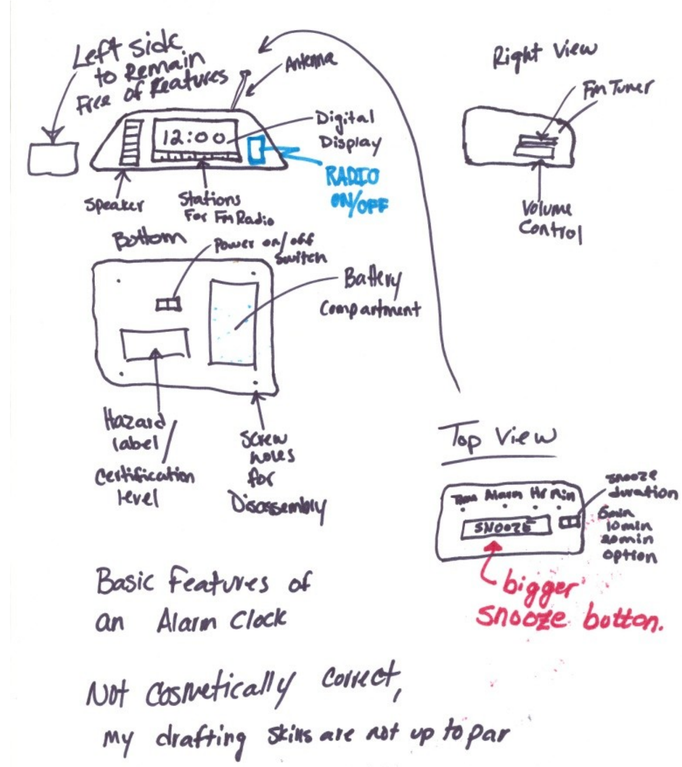

Figure 5. SAMPLE CONTROL GROUP CONCEPT

A representative concept from the control group is reproduced in Figure 5. The clock is a standard battery powered radio alarm clock with a digital display and antenna.

Figure 6 illustrates a sample concept from the subject group. The alarm clock takes the form of an earpiece. The user places the earpiece into their ear before going to sleep and then programs the alarm time with the use of the digital remote control.

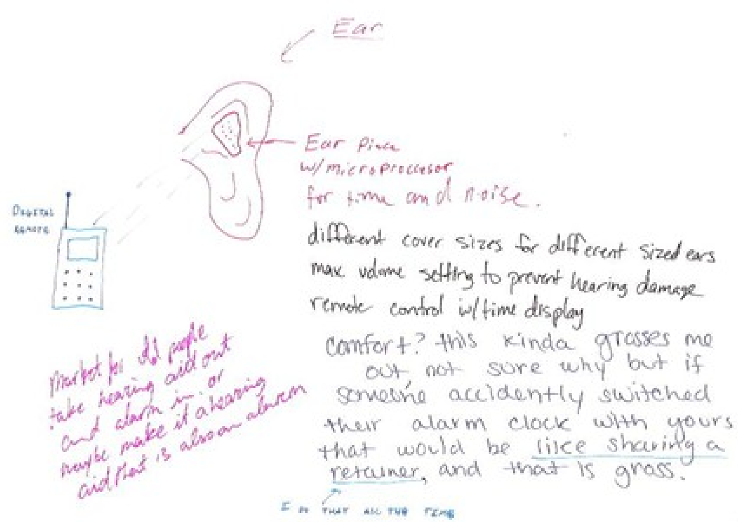

Figure 6. SAMPLE SUBJECT GROUP CONCEPT

As shown in Table 5, each concept is decomposed into its features before applying the metrics. Any features labeled standard are found to be common features in existing alarm clocks such as battery power for the energy source or a beeping sound for the mode of alarm. Non-standard features are labeled with a descriptor, such as the earpiece layout of the subject group concept. After the features are identified, each concept is analyzed with the originality and quality metrics. The results are recorded in Tables 6 and 7.

Table 5. FEATURES OF SAMPLE CONCEPTS

	Control Group Concept	Subject Group Concept
Mode of Alarm	Standard	Standard
Display Type	Standard	Standard
Information Shown	Standard	Standard
Mode of Input	Standard	Remote
Energy Source	Standard	Standard
Snooze	Standard	None
Music	Live	Standard
Alternative Use	Standard	Hearing aid
Shape/Layout	Standard	Earpiece

Table 6. ORIGINALITY ANALYSIS OF SAMPLE CONCEPTS

	Control Group Concept	Subject Group Concept
Mode of Alarm	0	0
Display Type	0	0
Information Shown	0	0
Mode of Input	0	5
Energy Source	0	0
Snooze	0	0
Music	0	0
Alternative Use	0	7.5
Shape/Layout	0	7.5
Maximum Originality Score	**0**	**7.5**

Table 6 summarizes the originality analysis of both concepts. The control group concept was very comparable to standard alarm clocks available in the marketplace. Based on the five-point originality metric, this concept was assigned a score of 0 (common) for each feature resulting in a maximum originality score of 0. The subject group concept had several standard features resulting in scores of 0 for those features, but it also had a few creative features such as its layout and its alternative use as an ear piece/hearing aid. Users can now be awakened without disturbing anyone else since the sound is emitted directly into the ear. This feature could be attractive to anyone sharing a room or bed such as couples, students in dormitories, or soldiers in barracks. Also, if a hearing aid is needed by the user, this product can act as both devices, eliminating the need for both products as separate units. It also comes with a remote for programming the alarm. The maximum originality score received by this concept was 7.5 (very interesting).

Table 7. QUALITY ANALYSIS OF SAMPLE CONCEPTS

	Control Group Concept	Subject Group Concept
Mode of Alarm	10	10
Display Type	10	10
Information Shown	10	10
Mode of Input	10	10
Energy Source	10	10
Snooze	10	10
Music	10	10
Alternative Use	10	10
Shape/Layout	10	10
Minimum Quality Score	**10**	**10**

Table 7 summarizes the results for the quality metric. Both the control and subject concepts were found to be completely feasible with every feature scoring 10 out of 10. Hearing aids and earpieces have been in existence for years and could easily be adapted to act as alarms.

4. RESULTS

Quality and originality scores were compiled separately for subject and control groups at each university. Maximum feature-level originality was recorded for each concept, along with minimum feature-level quality. T-tests were performed to evaluate the statistical significance of any differences between subject and control groups at each university and between subject and control groups across universities.

Originality Metric: Figure 7 illustrates the maximum feature-level originality scores, averaged over the subject and control groups at UMD. Results are reported with diamond plots, in which the green horizontal line in the middle of each diamond represents the mean for that particular group and the shorter green lines above and below it represent a single standard deviation from the mean. The black horizontal line in the middle of the graph represents the overall mean of the data from both subject and control groups. As shown in Figure 7, the subject group exhibited an average maximum feature-level originality score of 4.54, which was significantly higher than the control group's score of 3.30, with a p-value of 0.0033.

As shown in Figure 8, similar results were obtained at UT Austin, where the subject group outperformed the control group in terms of originality, with average maximum feature-level originality scores of 4.53 versus 3.63, respectively, and a p-value of 0.0062.

At both institutions, the EED method was found to have a significantly positive effect on the originality of the concepts generated by the participants. In addition, participants at both schools performed equally well with respect to originality. As shown in Figure 9, no significant difference was observed between participants at UMD and UT Austin with respect to maximum feature-level originality.

It is also important to understand the qualitative nature of the designs generated by the subject groups exposed to the EED method, and the features that led to higher originality scores for those concepts. Many of the concepts offered innovative means of waking the user, as an alternative to the typical auditory alarm with beeps or music. Upon implementation, most concepts would aid not only sensory disabled users but also typical users who seek something more effective than the typical alarm. Example concepts include alarms that spray small amounts of water on the sleeping person, alarms that gently vibrate a mattress or bed frame, wrist bands that vibrate or supply small shocks, eye patches that vibrate or blink bright lights into the user's eyes, and alarms that fire foam darts or other soft projectiles at the user.

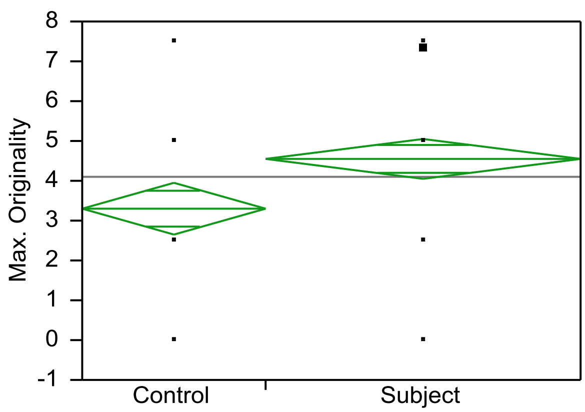

Figure 7. EFFECT OF EED METHOD ON ORIGINALITY AT UMD (P-VALUE 0.0033)

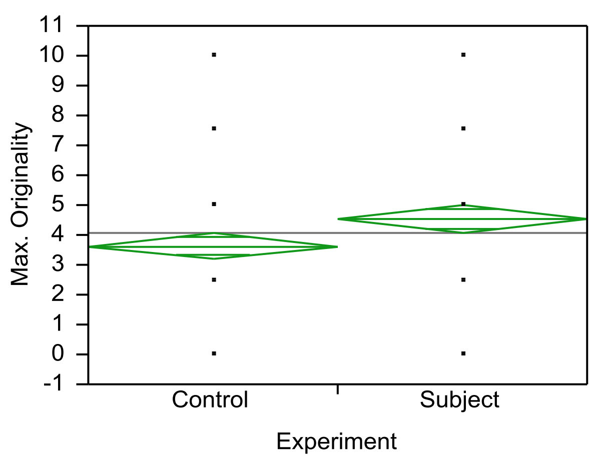

Figure 8. EFFECT OF EED METHOD ON ORIGINALITY AT UT AUSTIN (P-VALUE 0.0062)

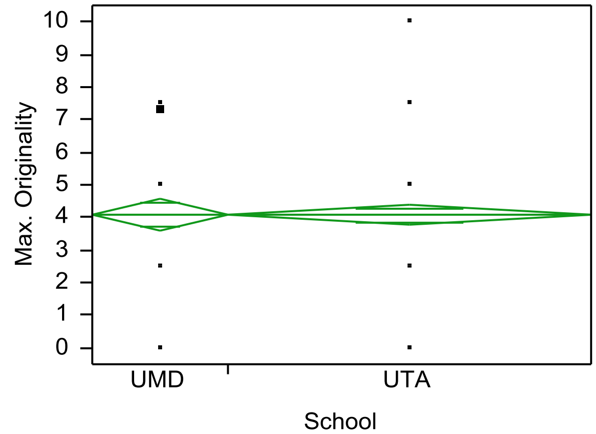

Figure 9. COMPARISON OF ORIGINALITY SCORES BETWEEN UMD AND UT AUSTIN (P-VALUE 0.99)

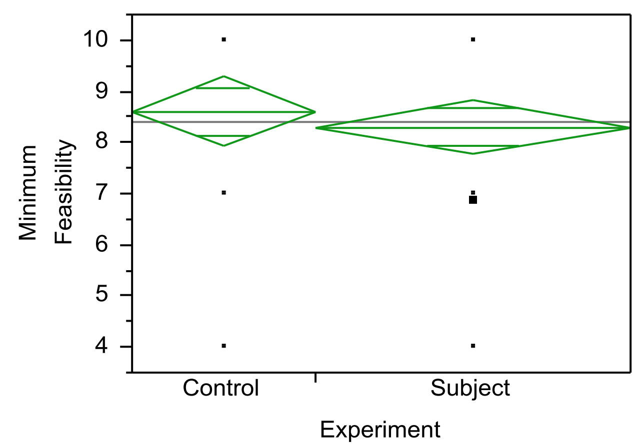

Figure 10. EFFECT OF EED METHOD ON QUALITY SCORES AT UMD (P-VALUE 0.49)

Quality Metric: Figure 10 illustrates the minimum feature-level quality scores, averaged over the subject and control groups at UMD. As shown, there was no statistically significant difference between the quality scores for the control group (avg. 8.60) and subject group (avg. 8.30), with a p-value of 0.49. For most concepts, the majority of the features scored 10 out of 10, which means that most of the designs were considered easy to manufacture.

As shown in Figure 11, similar results were obtained at UT Austin. No statistically significant difference was found between the minimum feature-level quality scores of the control (avg. 8.60) and subject groups (avg. 8.27), with a p-value of 0.24.

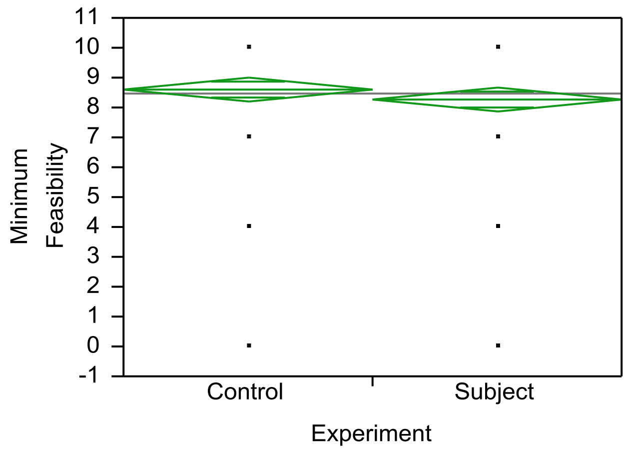

Figure 11. EFFECT OF EED METHOD ON QUALITY SCORES AT UT AUSTIN (P-VALUE 0.24)

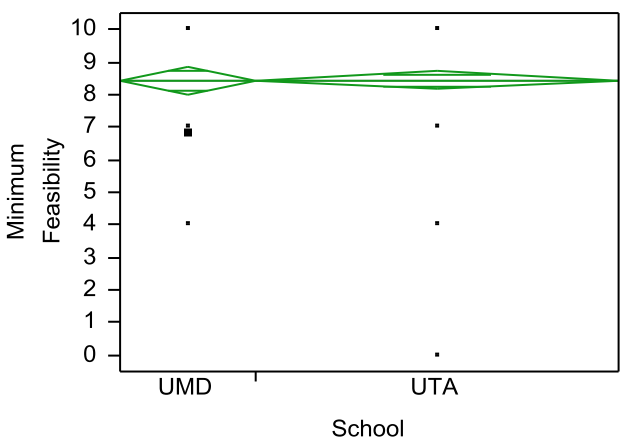

Figure 12. COMPARISON OF QUALITY SCORES BETWEEN UMD AND UT AUSTIN (P-VALUE 0.90)

Similarly to the comparison of the schools' creative ability, no significant difference was observed between minimum feature-level quality scores at UMD (avg. 8.41) and UT Austin (avg. 8.44), with a p-value of 0.90, as shown in Figure 12.

5. CONCLUSIONS

The Empathic Experience Design (EED) method was introduced as a structured conceptual design methodology intended to enhance creativity and innovation. Although empathy has been recognized as an important part of customer needs analysis, the EED method explicitly incorporates it into the concept generation method for the first time. As part of the EED method, designers engage in empathic experiences, which challenge their interactions with a prototype product to be redesigned. Those experiences precede a concept generation activity, which takes the form of a 6-3-5 method in this study.

The effectiveness of the EED method was tested with experiments conducted separately at two different universities: The University of Massachusetts Dartmouth and The University of Texas at Austin. The results of the experiments support the conclusion that the EED method positively influences the originality of resulting concepts, without significantly influencing the quality or technical feasibility of those concepts. Results were consistent across the two universities.

There are several opportunities for further research. It would be interesting to conduct further experiments with different products to ensure that the method works not only with alarm clocks, but with other products, as well. Since alarm clocks are relatively mature products, it would be interesting to conduct experiments with a newly introduced product with few competitors. It would also be interesting to isolate the effects of specific empathic experiences or situational disabilities on the characteristics of resulting designs. Finally, one of the advantages of the EED method may be its ability to help designers empathize with a variety of lead users and perhaps eliminate the need for lead users by allowing any designer to be more creative when exposed to the right empathic experiences. To test this hypothesis, it would be interesting to compare lead users and representative designers in a concept generation exercise.

ACKNOWLEDGEMENTS

The authors would like to acknowledge support from the National Science Foundation under Grant No. CMMI-0825461/0825713. Any opinions, findings and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the sponsors.

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